ประกาศบริษัท ปตท. จำกัด (มหาชน)

ทะเบียนเลขที่ 0107544000108

เรื่อง ยกเลิก จัดจ้าง Revamp PLC Fire & Gas Tank GSP6 with New HMI พื้นที่ Tank Farm

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ตามประกาศแจ้งความ บริษัท ปตท. จำกัด(มหาชน) ที่ 1120017354 ลงวันที่ 10 พฤษภาคม 2565 เรื่อง จัดจ้าง Revamp PLC Fire & Gas Tank GSP6 with New HMI พื้นที่ Tank Farm โดยมีกำหนดรับซองเสนอราคาเมื่อวันที่ 27 พฤษภาคม 2565 ดังความละเอียดแจ้งแล้ว นั้น

การประมูลครั้งนี้ มีผู้มายื่นซองเพียงรายเดียว ปตท. จึงเห็นควรยกเลิกประมูลในครั้งนี้ และจะดำเนินการตามที่เห็นสมควรต่อไป

ฉะนั้น จึงประกาศมาเพื่อทราบโดยทั่วกัน

ประกาศ ณ วันที่ 08 มิถุนายน 2565

(กฤษรา คงนวล)

ผู้จัดการแผนกจัดหาพัสดุ

แผนกจัดหาพัสดุ

ประกาศบริษัท ปตท. จำกัด (มหาชน)

ทะเบียนเลขที่ 0107544000108

เลขที่ 1120017354

เรื่อง จัดจ้าง Revamp PLC Fire & Gas Tank GSP6 with New HMI พื้นที่ Tank Farm

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ด้วยบริษัท ปตท. จำกัด(มหาชน) มีความประสงค์ที่จะประมูลเป็นลายลักษณ์อักษร จัดจ้าง Revamp PLC Fire & Gas Tank GSP6 with New HMI พื้นที่ Tank Farm

สถานที่ส่งมอบ ณ โรงแยกก๊าซธรรมชาติระยอง เลขที่ 555 ถนน สุขุมวิท ตำบล มาบตาพุด อำเภอ เมือง จังหวัด ระยอง 21150

กำหนดส่งมอบ รายละเอียดตามข้อกำหนดข้อที่ 7

ตามเงื่อนไขรายละเอียดรูปแบบและเอกสารแนบท้ายแจ้งความ ซึ่งถือเป็นส่วนหนึ่งของแจ้งความ ดังนี้

- คำรับรองการมีคุณสมบัติในการเข้าทำธุรกรรมกับ ปตท.	1 แผ่น
- รายละเอียดตามข้อกำหนด ปตท.	1 ชุด
- ตัวอย่างหนังสือมอบอำนาจ	1 แผ่น
- ตัวอย่างแบบสัญญาค้ำประกันธนาคาร	1 แผ่น
- เอกสารประกอบการปฏิบัติตาม พ.ร.บ. คุ้มครองข้อมูลส่วนบุคคล	1 ชุด
- คำแนะนำในการจัดทำเอกสาร	1 ชุด

กำหนดฟังคำชี้แจงพร้อมกันที่ Video Conference ผ่าน Software Microsoft Teams วันที่ 18 พฤษภาคม 2565 โดยลงทะเบียนเข้าฟังคำชี้แจง เวลา 9:45 ถึง 10:00 น.

และชี้แจง เวลา 10:00 น. (ผู้ชี้แจง นาย เสกข์สิริ เรียงทองหลาง รหัสพนักงาน 590085 โทร 087-606-0548)

หากไม่มาฟังคำชี้แจง ปตท. จะถือว่า ผู้นั้นสละสิทธิ์ในการเสนอราคาและไม่มีสิทธิ์ในการเสนอราคา

กำหนดยื่นซองราคา ซองหลักฐาน ซองเทคนิค ในวันที่ 27 พฤษภาคม 2565 เวลา 08:30-15:00 น. ณ สถานที่ดังนี้

- แผนกจัดหาพัสดุ ส่วนจัดหาและบริหารพัสดุโรงแยกก๊าซ โรงแยกก๊าซธรรมชาติ ปตท. เลขที่ 555 ถ.สุขุมวิท ต.มาบตาพุด อ.เมือง จ.ระยอง 21150

ผู้สนใจติดต่อขอซื้อรายละเอียดได้ในราคาชุดละ - บาท (รวมภาษีมูลค่าเพิ่มแล้ว) ตั้งแต่วันที่ 10 พฤษภาคม 2565 จนถึงวันที่ 17 พฤษภาคม 2565 ระหว่างเวลา 08:30 -17:00 น. ยกเว้นวันหยุดราชการ (หมายเหตุ : เนื่องจากสถานการณ์ COVID-19 เพื่อป้องกันการแพร่ระบาด หากผู้ค้าประสงค์เข้าร่วมประมูลขอให้แจ้งผ่าน E-mail : kunsriwimol_b@pttplc.com และ Chawintorn.t@pttplc.com ภายในวันที่ที่กำหนดบนหน้าประกาศ โดยระบุเลข PR No. และ E-mail ผู้แทนบริษัทที่จะเข้ารับฟังคำชี้แจงด้วย

(ผู้ค้าไม่ต้องมาลงทะเบียนรับแบบ ณ แผนกจัดหาพัสดุ)) ณ สถานที่ดังนี้

- แผนกจัดหาพัสดุ ส่วนจัดหาและบริหารพัสดุโรงแยกก๊าซ โรงแยกก๊าซธรรมชาติ ปตท. เลขที่ 555 ถ.สุขุมวิท ต.มาบตาพุด อ.เมือง จ.ระยอง 21150 (นายชวินธร ตระกูลเงิน โทรศัพท์ 038676179)

ประกาศ ณ วันที่ 10 พฤษภาคม 2565

(นายกฤษรา คงนวล)

ผู้จัดการแผนกจัดหาพัสดุ

แผนกจัดหาพัสดุ

บริษัท ปตท. จำกัด (มหาชน) **PTT Public Company Limited**		ข้อกำหนด (Terms Of Reference: TOR)
เรื่อง : Revamp PLC Fire & Gas Tank GSP6 with New HMI		
จัดทำโดย : นายเสกข์สิริ เรียงทองหลาง นายชัยสิทธิ์ วลีสุขสันต์	วันที่จัดทำ : 06 พฤษภาคม 2565 Rev.2 SAP PR No.1120017354	หน่วยงานที่จัดทำ : ส่วนบำรุงรักษาระบบควบคุม

ระบบมาตรฐานที่เกี่ยวข้อง

☐ Quality	■ Safety	☐ Health	☐ Environment	☐ Lab	☐ Energy

ขอบเขตของงาน (TOR)

บริษัท ปตท. จำกัด (มหาชน) ซึ่งต่อไปเรียกว่า ปตท. มีความประสงค์จะจ้างพร้อมติดตั้งงาน Revamp PLC Fire & Gas Tank GSP6 with New HMI เพื่อใช้งานที่ Tank farm โดยมีข้อกำหนดดังต่อไปนี้

1. วัตถุประสงค์ในการจัดหา

เพื่อ Revamp PLC Fire & Gas Tank GSP6 with New HMI

2. คุณสมบัติของผู้ยื่นข้อเสนอ

2.1 ต้องเป็นบุคคลธรรมดาหรือนิติบุคคลผู้มีอาชีพประกอบกิจการตามที่เสนอ

2.2 ต้องไม่เคยถูก ปตท. บอกเลิกสัญญาใดๆ อันเนื่องมาจากการกระทำโดยทุจริต

2.3 ต้องไม่เป็นคู่ความในคดีใดๆ หรือคู่พิพาทในข้อพิพาทอนุญาโตตุลาการใดๆ กับ ปตท. ไม่ว่าจะเป็นผู้ค้ารายที่ได้ขึ้นทะเบียนผู้ค้าไว้กับ ปตท. หรือไม่ก็ตาม เว้นแต่คดีหรือข้อพิพาทนั้นถึงที่สุดแล้ว

ทั้งนี้ ผู้ยื่นข้อเสนอตามข้อ 2.2 และ 2.3 ให้รวมถึงหุ้นส่วนหรือกรรมการของผู้ยื่นข้อเสนอด้วย

2.4 ต้องไม่เป็นบุคคลหรือนิติบุคคลซึ่งถูกขึ้นบัญชีผู้ทิ้งงานของ ปตท. และไม่เป็นบุคคลหรือนิติบุคคลซึ่งถูกระบุชื่อไว้ในรายชื่อผู้ทิ้งงานของหน่วยงานของรัฐในระบบเครือข่ายสารสนเทศของกรมบัญชีกลาง

2.5 ต้องเป็นรายเดียวกับผู้ซื้อ/รับเอกสารเสนอราคาจาก ปตท. และจะโอนสิทธิ์ให้ผู้ประกอบการรายอื่นเสนอราคาแทนไม่ได้

ในกรณีที่ผู้เสนอราคาเป็นกลุ่มบุคคลในลักษณะ Partnership / Consortium / Joint Venture จะต้องมีสมาชิกในกลุ่มรายใดรายหนึ่ง เป็นผู้ซื้อ/รับเอกสารเสนอราคาจาก ปตท. ทั้งนี้ ผู้เสนอราคาที่มีลักษณะเป็น Partnership / Consortium / Joint Venture ดังกล่าว จะต้องรับผิดชอบต่อ ปตท.ในฐานะลูกหนี้ร่วมด้วย

(หมายเหตุ การเสนอราคาเป็นกลุ่มบุคคลในลักษณะ Partnership / Consortium / Joint Venture นั้น จะต้องมีการระบุไว้โดยเฉพาะเจาะจงในรายละเอียดการจัดซื้อ/จัดจ้าง (TOR) ว่ากลุ่มบุคคลดังกล่าวสามารถเข้าร่วมการเสนอราคาได้)

2.6 ต้องไม่เป็นผู้มีผลประโยชน์ร่วมกันกับผู้ยื่นข้อเสนอรายอื่นที่เข้ายื่นข้อเสนอให้แก่ ปตท. ณ วันประกาศประมูล หรือไม่เป็นผู้กระทำการอันเป็นการขัดขวางการแข่งขันอย่างเป็นธรรมในการประมูลครั้งนี้

2.7 ต้องไม่เคยได้รับการภาคทัณฑ์หรือถูกยกเลิกการจัดจ้าง เนื่องจากส่งของไม่ถูกต้องตามข้อกำหนด หรือไม่ปฏิบัติตามกฎความปลอดภัย อาชีวอนามัยและสิ่งแวดล้อม ของโรงแยกก๊าซธรรมชาติระยอง ปตท. หรือคลังปิโตรเลียม

ภาคตะวันออกหรือโรงกลั่นน้ำมันหรือโรงงานปิโตรเคมี อื่นๆ

2.8 ต้องแนบเอกสารหนังสือคำรับรองการมีคุณสมบัติในการเข้าทำธุรกรรมกับ ปตท. ทุกครั้งที่เสนอราคา

2.9 ผู้เสนอราคาที่เป็นนิติบุคคลจะต้องมีทุนจดทะเบียน ไม่ต่ำกว่า 2,000,000 บาท

2.10 ผู้เสนอราคาต้องไม่เคยได้รับผลประเมินหลังส่งมอบสินค้าและบริการประจำปี ในระดับควรปรับปรุง (D) ของสายงานแยกก๊าซธรรมชาติ บริษัท ปตท. จำกัด (มหาชน) ในช่วงระยะเวลาย้อนหลัง 1 ปี

***** ข้อมูลเพิ่มเติมตามเอกสารแนบ "TOR Form_ข้อ_02_คุณสมบัติของผู้ยื่นข้อเสนอ"***********

3. หลักฐานการยื่นข้อเสนอ

ในการยื่นข้อเสนอผู้ยื่นข้อเสนอจะต้องจัดเอกสารใส่ซองปิดผนึกให้เรียบร้อยโดยแยกเป็นแต่ละซองดังนี้

(3.1) ซองคุณสมบัติของผู้ค้า

3.1.1 กรณีเป็นร้าน ให้แนบสำเนาใบทะเบียนภาษีมูลค่าเพิ่มและสำเนาใบทะเบียนพาณิชย์ พร้อมทั้งให้เจ้าของหรือผู้จัดการร้านลงลายมือชื่อรับรองสำเนาถูกต้องและประทับตรา (ถ้ามี) ของร้านด้วย

3.1.2 กรณีเป็นบริษัทหรือห้างหุ้นส่วนที่จดทะเบียนในประเทศไทย ให้แนบหลักฐานหนังสือรับรองการจดทะเบียนของกระทรวงพาณิชย์ที่มีอายุไม่เกิน 6 เดือน นับถัดจากวันรับรองจนถึงวันยื่นซองใบเสนอราคา และหากหลักฐานดังกล่าวไม่ใช่ต้นฉบับ ผู้มีอำนาจลงนามผูกพันบริษัทหรือห้างหุ้นส่วนจะต้องลงลายมือชื่อรับรองสำเนาถูกต้องและประทับตรา (ถ้ามี) ของบริษัทหรือห้างหุ้นส่วนด้วย

3.1.3 ในกรณีผู้ยื่นข้อเสนอเป็นบุคคลหรือองค์กรอื่นๆ เช่น มหาวิทยาลัย สมาคม มูลนิธิ ให้ยื่นเอกสารแสดงคุณสมบัติของผู้ยื่นข้อเสนอที่รับรองโดยหน่วยงานราชการ

3.1.4 กรณีเป็นบริษัทหรือห้างหุ้นส่วนที่จดทะเบียนในต่างประเทศ ให้แนบหนังสือรับรองของสถานทูตไทย หรือกงสุลไทย หรือทูตพาณิชย์ไทย รับรองการจดทะเบียน วัตถุประสงค์ และอำนาจในการทำนิติกรรมของนิติบุคคลนั้น ตามกฎหมายของประเทศที่นิติบุคคลนั้นก่อตั้ง และจะต้องไม่เป็นผู้ได้รับเอกสิทธิ์หรือความคุ้มกันซึ่งอาจปฏิเสธไม่ยอมขึ้นศาลไทย เว้นแต่รัฐบาลของผู้ยื่นข้อเสนอนั้นได้มีคำสั่งให้สละเอกสิทธิ์และความคุ้มกันเช่นว่านั้นแล้ว

3.1.5 ในกรณีที่ผู้มีอำนาจลงนามผูกพันร้านหรือบริษัทหรือห้างหุ้นส่วนไม่ได้ลงนามด้วยตนเอง การมอบอำนาจให้ผู้อื่นเป็นผู้ลงนามในเอกสารที่เกี่ยวข้องกับการเสนอราคาต่างๆ จะต้องมีหนังสือมอบอำนาจโดยการระบุการมอบอำนาจไว้ให้ถูกต้องและ

ชัดเจน โดยผู้เสนอราคาอาจให้บุคคลอื่นเป็นผู้ยื่น/นำส่งซองเอกสารเสนอราคาดังกล่าวให้แก่ ปตท.แทนตนได้ โดยผู้เสนอราคารับรองว่าจะรับผิดชอบต่อ ปตท.ในการนำส่งเอกสารแทนตนดังกล่าวทุกประการ เสมือนเป็นตัวแทนของตนด้วย

3.1.6 สำเนาบัตรประชาชน/สำเนาหนังสือเดินทาง (Passport) ของผู้มีอำนาจลงนามผูกพันพร้อมลงนามรับรองสำเนาถูกต้อง (ในกรณีกรรมการผู้มีอำนาจลงนามในใบเสนอราคาเอง) หรือ สำเนาบัตรประชาชน /สำเนาหนังสือเดินทาง (Passport) ของผู้มอบอำนาจและผู้รับมอบอำนาจพร้อมลงนามรับรองสำเนาถูกต้อง (ในกรณีมีการมอบอำนาจ)

3.1.7 ในกรณีที่จดทะเบียนภาษีมูลค่าเพิ่มไว้จะต้องแนบสำเนา ภพ. 20 ด้วย

3.1.8 เอกสารหนังสือคำรับรองการมีคุณสมบัติในการเข้าทำธุรกรรมกับ ปตท.

(3.2) ซองเอกสารเทคนิค

***** ข้อมูลตามเอกสารแนบ "TOR Form_ข้อ_03.2_ซองเอกสารเทคนิค "***********

(3.3) ซองใบเสนอราคา

3.3.1 ซองราคา

3.3.1.1. ใบเสนอราคา เป็นราคาในลักษณะเหมารวม (LUMP SUM PRICE) โดยรวมค่าวัสดุ, ค่าแรงงาน, ค่าดำเนินการ, ค่าภาษี, ค่าประกันภัย และค่าใช้จ่ายอื่น ๆ ยกเว้นภาษีมูลค่าเพิ่ม

3.3.1.2. Break Down Price

3.3.1.2.1. เสนอราคาตามรายละเอียดในเอกสารแนบ "TOR Form_ข้อ_03.3_ซองใบเสนอราคา_BOM รายการเสนอราคา"

3.3.1.2.2. รายละเอียดตามข้อกำหนด โดยขนาดและจำนวนที่ระบุในเอกสารนี้ เป็นการประเมินเบื้องต้นจากทาง ปตท. ทางผู้เสนอราคาจะต้องประเมินขนาดและจำนวนที่แท้จริงด้วยตัวเองอีกครั้งจากการตรวจสอบหน้างาน หากมีรายการเพิ่มเติมจากข้อกำหนด ให้ทางผู้เสนอราคาระบุมาเพิ่มเติมทันที

3.3.1.2.3. หากมีรายการเพิ่มเติมจากที่กำหนดไว้ ให้ผู้เสนอราคาลงรายละเอียดต่อท้ายไปเป็นลำดับ

3.3.1.3. ผู้เสนอราคาจะต้องผ่านขั้นตอน การพิจารณาคัดเลือกทางด้านเทคนิคก่อน จึงจะเปิดซองเสนอราคา

4. การเสนอราคา

4.1 ผู้ยื่นข้อเสนอต้องกรอกราคาต่อหน่วยหรือต่อรายการและราคารวมลงในใบเสนอราคาโดยใช้แบบฟอร์มใบเสนอราคาของ ปตท. หรือ ใช้แบบฟอร์มใบเสนอราคาของผู้ยื่นข้อเสนอเอง โดยจะต้องมีเนื้อหาตามแบบฟอร์มใบเสนอราคาของ ปตท. เช่น วันที่เสนอราคา ชื่อผู้ยื่นข้อเสนอ เรื่องที่เสนอราคา ราคาต่อหน่วยหรือต่อรายการ และราคารวม ข้อความยอมรับการปฏิบัติตามเงื่อนไขของ ปตท. เป็นต้น โดยต้องเป็นราคาไม่รวมภาษีมูลค่าเพิ่มและต้อง

เสนอราคาเป็นเงิน THB รวมค่าใช้จ่ายทั้งหมดแล้วจนกระทั่งส่งมอบ โดยผู้ยื่นข้อเสนอต้องกรอกจำนวนเงินเป็นตัวเลขและตัวหนังสือลงในใบเสนอราคาให้ชัดเจนในกรณีที่มีการขูดลบ หรือขีดฆ่า ต้องลงลายมือชื่อผู้มีอำนาจและประทับตรากำกับ (ถ้ามี) หากราคาต่อหน่วยหรือต่อรายการไม่ตรงกับราคารวม หรือตัวเลขกับตัวหนังสือไม่ตรงกัน ให้นำบทบัญญัติในประมวลกฎหมายแพ่งและพาณิชย์มาใช้บังคับ ทั้งนี้ ราคาที่เสนอจะต้องยืนราคาตามเวลาที่ ปตท. กำหนด โดยผู้ยื่นข้อเสนอต้องยืนราคาไม่น้อยกว่า 90 วัน นับถัดจากวันที่เสนอราคา และเมื่อผู้ยื่นข้อเสนอทำการยื่นข้อเสนอตามข้อ 3 แล้ว จะถอนคืนไม่ได้

4.2 เมื่อพ้นกำหนดเวลายื่นข้อเสนอและเสนอราคาแล้ว ปตท. จะไม่รับเอกสารการยื่นข้อเสนอและเสนอราคาใดๆ โดยเด็ดขาด

4.3 คณะกรรมการจัดหาสินค้าของ ปตท. จะดำเนินการตรวจสอบคุณสมบัติของผู้ยื่นข้อเสนอแต่ละรายว่า มีผู้ยื่นข้อเสนอที่มีผลประโยชน์ร่วมกันกับผู้ยื่นข้อเสนอรายอื่นหรือไม่ หากปรากฏว่าผู้ยื่นข้อเสนอรายใดเป็นผู้ยื่นข้อเสนอที่มีผลประโยชน์ร่วมกันกับผู้ยื่นข้อเสนอรายอื่น คณะกรรมการจัดหาสินค้าของ ปตท. จะตัดรายชื่อผู้ยื่นข้อเสนอที่มีผลประโยชน์ร่วมกันนั้นออกจากการเป็นผู้ยื่นข้อเสนอ

5. หลักประกันซองในการเสนอราคา

ในการเสนอราคาครั้งนี้ ไม่มีการวางหลักประกันซองเสนอราคา

6. หลักเกณฑ์และสิทธิในการพิจารณา

6.1 ในการพิจารณาผลการยื่นข้อเสนองานครั้งนี้ ปตท. จะพิจารณาตัดสินโดยใช้หลักเกณฑ์ราคา

6.2 ปตท. จะพิจารณาจากราคารวมต่ำสุด

6.3 หากผู้ยื่นข้อเสนอรายใดมีคุณสมบัติไม่ถูกต้องตามข้อ 2 หรือยื่นหลักฐานการยื่นข้อเสนอไม่ถูกต้องหรือไม่ครบถ้วนตามข้อ 3 หรือยื่นเสนอราคาไม่ถูกต้องตามข้อ 4 คณะกรรมการจัดหาสินค้าของ ปตท. จะไม่รับพิจารณาข้อเสนอของผู้ยื่นข้อเสนอรายนั้น เว้นแต่ผู้ยื่นข้อเสนอรายใดเสนอเอกสารทางเทคนิคหรือรายละเอียดคุณลักษณะเฉพาะของงานที่จะจ้างไม่ครบถ้วน หรือเสนอรายละเอียดแตกต่างไปจากเงื่อนไขที่ ปตท. กำหนดในส่วนที่มิใช่สาระสำคัญและความแตกต่างนั้นไม่มีผลทำให้เกิดการได้เปรียบเสียเปรียบต่อผู้ยื่นข้อเสนอรายอื่น หรือเป็นการผิดพลาดเล็กน้อย คณะกรรมการจัดหาสินค้าของ ปตท. อาจพิจารณาผ่อนปรนการตัดสิทธิผู้ยื่นข้อเสนอรายนั้น

6.4 ปตท. สงวนสิทธิ์ไม่พิจารณาข้อเสนอของผู้ยื่นข้อเสนอโดยไม่มีการผ่อนผันในกรณีดังต่อไปนี้

(1) ไม่ปรากฏชื่อผู้ยื่นข้อเสนอรายนั้นในบัญชีรายชื่อผู้ซื้อหรือผู้รับเอกสารงานประมูลของ ปตท.

(2) เสนอรายละเอียดแตกต่างไปจากเงื่อนไขที่กำหนดในขอบเขตของงานที่เป็นสาระสำคัญ หรือมีผลทำให้เกิดความได้เปรียบเสียเปรียบแก่ผู้ยื่นข้อเสนอรายอื่น

6.5 ปตท. จะพิจารณายกเลิกการประมูลงานและลงโทษผู้ยื่นข้อเสนอเป็นผู้ทิ้งงาน ไม่ว่าจะเป็นผู้ยื่นข้อเสนอที่ได้รับการคัดเลือกหรือไม่ก็ตาม หากมีเหตุที่เชื่อถือได้ว่าการยื่นข้อเสนอกระทำการ โดยไม่สุจริต เช่น การเสนอเอกสารอันเป็นเท็จ หรือใช้ชื่อบุคคลธรรมดา หรือนิติบุคคลอื่นมาเสนอราคาแทน เป็นต้น

ในกรณีที่ผู้ยื่นข้อเสนอรายที่เสนอราคาต่ำสุด เสนอราคาต่ำจนคาดหมายได้ว่าไม่อาจดำเนินงานตามขอบเขตของงานครั้งนี้ได้ คณะกรรมการจัดหาสินค้าของ ปตท. จะให้ผู้ยื่นข้อเสนอนั้นชี้แจงและแสดงหลักฐานที่ทำให้เชื่อได้ว่าผู้ยื่นข้อเสนอสามารถดำเนินการตามขอบเขตของงานครั้งนี้ให้เสร็จสมบูรณ์ หากคำชี้แจงไม่เป็นที่รับฟังได้ ปตท. มีสิทธิที่จะไม่รับข้อเสนอหรือไม่รับราคาของผู้ยื่นข้อเสนอรายนั้น ทั้งนี้ ผู้ยื่นข้อเสนอดังกล่าวไม่มีสิทธิเรียกร้องค่าใช้จ่ายหรือค่าเสียหายใดๆ จาก ปตท. ถ้าหากมีปัญหาที่ไม่สามารถตกลงกันได้ ให้ถือว่าคำวินิจฉัยของ ปตท. เป็นที่สิ้นสุด

6.6 ก่อนลงนามในสัญญา ปตท. อาจประกาศยกเลิกการประมูลงาน หากปรากฏว่ามีการกระทำที่เข้าลักษณะผู้ยื่นข้อเสนอที่ชนะการประมูลหรือที่ได้รับการคัดเลือกมีผลประโยชน์ร่วมกัน หรือมีส่วนได้เสียกับผู้ยื่นข้อเสนอรายอื่น หรือขัดขวางการแข่งขันอย่างเป็นธรรม หรือสมยอมกันกับผู้ยื่นข้อเสนอรายอื่น หรือเจ้าหน้าที่ในการเสนอราคา หรือส่อว่ากระทำการทุจริตอื่นใดในการเสนอราคา

7. การส่งมอบงาน

7.1 **กำหนดการส่งมอบ** ผู้รับจ้างต้องส่งมอบงานจ้างให้กับ บริษัท ปตท. จำกัด (มหาชน) โดยมีรายละเอียดกำหนดส่งมอบ ไม่นับรวมระยะเวลาที่ ปตท. ไม่อนุญาตให้เข้าดำเนินงาน/สั่งหยุดงาน

จำนวน 3 งวด งวดที่ 1 ส่งมอบสินค้าตามข้อกำหนดข้อที่ 16 ส่วนของ Scope of supply ทั้งหมด ยกเว้นข้อ 6.4 ภายใน 150 วัน (ไม่เว้นวันหยุด) นับถัดจากผู้รับจ้างได้รับใบสั่งจ้างหรือหนังสือสนองจ้าง จาก ปตท.

งวดที่ 2 ส่งมอบงานตามข้อกำหนดข้อที่ 16 ส่วนของ Scope of work Phase 1 ภายใน 240 วัน (ไม่เว้นวันหยุด) นับถัดจากผู้รับจ้างได้รับใบสั่งจ้างหรือหนังสือสนองจ้าง จาก ปตท.

งวดที่ 3 ส่งมอบสินค้าตามข้อกำหนดข้อที่ 16 ส่วนของ Scope of supply ข้อ 6.4 และส่งมอบงานครบทั้งหมดตามข้อกำหนดข้อที่ 16 ส่วนของ scope of work phase 2 ภายใน 180 วัน (ไม่เว้นวันหยุด) นับถัดจาก วันที่ ปตท.มีหนังสือแจ้งให้ส่งสินค้าหรือส่งมอบงาน โดยมีระยะเวลาสิ้นสุดสัญญาเมื่อครบมูลค่าตามสัญญาหรือถึงวันที่ 31 ธันวาคม 2566 แล้วแต่อย่างใดอย่างหนึ่งถึงก่อน

8. สถานที่ส่งมอบ

ผู้รับจ้างต้องส่งมอบงานจ้างทั้งหมดที่ โรงแยกก๊าซธรรมชาติระยอง เลขที่ 555 ถนน สุขุมวิท ตำบล มาบตาพุด อำเภอ เมือง จังหวัด ระยอง 21150

9. การจ่ายเงิน

9.1 ปตท. จะชำระเงินเป็นงวดๆ โดยแบ่งออกเป็น3งวด

งวดที่ 1 ชำระเงินจำนวน 30% ของวงเงินตามสัญญา เมื่อผู้รับจ้าง ส่งมอบสินค้าตามข้อกำหนดข้อที่ 16 ส่วนของ Scope of supply ทั้งหมด ยกเว้นข้อ 6.4

งวดที่ 2 ชำระเงินจำนวน 30% ของวงเงินตามสัญญา เมื่อผู้รับจ้าง ส่งมอบงานตามข้อกำหนดข้อที่ 16 ส่วนของ Scope of work Phase 1

งวดที่ 3 ชำระเงินจำนวน 40% ของวงเงินตามสัญญา เมื่อผู้รับจ้าง ส่งมอบสินค้าตามข้อกำหนดข้อที่ 16 ส่วนของ Scope of supply ข้อ 6.4 และส่งมอบงานครบทั้งหมดตามข้อกำหนดข้อที่ 16 ส่วนของ scope of work phase 2

ทั้งนี้ ปตท. จะชำระเงิน เมื่อครบ 30 วัน นับถัดจากวันที่คณะกรรมการตรวจรับ ของ ปตท. ได้ทำการตรวจรับงานถูกต้องครบ ถ้วนเรียบร้อยแล้วในแต่ละงวด

10. อัตราค่าปรับ

กรณีการส่งมอบงานล่าช้ากว่าที่ทาง ปตท. กำหนดจะคิดค่าปรับวันละ 0.1% ต่อวัน (ไม่เว้นวันหยุดราชการ) ของมูลค่าจ้างตามสัญญา (ไม่รวมภาษีมูลค่าเพิ่ม)

11. การรับประกันความชำรุดบกพร่อง

ผู้รับจ้างจะต้องรับประกันความชำรุดบกพร่องของงานจ้างที่เกิดขึ้นภายในระยะเวลาไม่น้อยกว่า 12 เดือนนับตั้งแต่วันที่ ปตท. ได้รับมอบงาน และคณะกรรมการตรวจรับได้ตรวจรับงานครบถ้วนถูกต้องแล้ว โดยต้องรีบจัดการซ่อมแซมแก้ไขให้ใช้การได้ดีดังเดิมภายใน 30วัน นับถัดจากวันที่ได้รับแจ้งความชำรุดข้อบกพร่อง

12. การทำสัญญาจ้างและหลักประกันสัญญา

12.1 ผู้ที่ ปตท. ตกลงด้วยในการจ้าง จะต้องดำเนินการดังนี้

(1) กรณีการจัดหาที่มีวงเงินการจัดหาไม่เกิน 5 ล้านบาท หรือไม่อยู่ในเงื่อนไขของ ปตท. ที่จะต้องจัดทำเป็นรูปแบบสัญญาให้ผู้ที่ ปตท. ตกลงด้วยในการจ้างไปติดต่อขอรับใบสั่งจ้างภายใน 7 วันนับถัดจากวันที่ ปตท. แจ้ง (กรณีไม่ต้องมีการวางหลักประกันสัญญา) หรือภายใน 15 วัน นับถัดจากวันที่ปตท. แจ้ง (กรณีที่ต้องมีการวางหลักประกันสัญญา)

(2) กรณีการจัดหาที่มีวงเงินการจัดหาเกินกว่า 5 ล้านบาท หรือ ปตท. กำหนดเงื่อนไขให้จัดทำเป็นรูปแบบสัญญาให้ผู้ที่ ปตท. ตกลงด้วยในการจ้างไปติดต่อขอรับหนังสือสนองจ้างภายใน 7 วันนับถัดจากวันที่ ปตท. แจ้ง และจะต้องไปติดต่อเพื่อทำสัญญากับ ปตท. ภายในระยะเวลาที่กำหนดในหนังสือสนองนั้น

หากผู้ที่ ปตท. ตกลงด้วยในการจ้างไม่ดำเนินการตาม ข้อ 12.1 (1) หรือ 12.1 (2) ดังกล่าว ปตท. จะริบหลักประกัน (ถ้ามี) และหาก ปตท. ต้องจัดหาจากบุคคลอื่นแทนในราคาที่สูงกว่าราคาของผู้ที่ ปตท. ตกลงในการจ้างแล้ว ผู้นั้นจะต้องรับผิดชอบชดใช้ราคาที่เพิ่มขึ้นให้กับ ปตท. ภายใน 30 วัน นับถัดจากวันที่ได้รับแจ้งจาก ปตท. นอกจากนี้ ปตท. สงวนสิทธิ์ที่จะเรียกร้องค่าเสียหายทั้งหมดที่เกิดขึ้นเนื่องจากเหตุดังกล่าวด้วย

12.2 ในการทำสัญญาหรือใบสั่งจ้างนั้น ในกรณีที่ต้องมีการวางหลักประกันสัญญา และรายการละเอียดแนบท้ายการสั่งจ้าง มิได้กำหนดการวางหลักประกันสัญญาไว้เป็นอย่างอื่นแล้ว ให้ผู้เสนอราคาที่ ปตท. ตกลงจ้าง (ซึ่งต่อไปจะเรียกว่า “ผู้รับจ้าง”) จะต้องนำเงินสดหรือหนังสือค้ำประกันของธนาคารหรือพันธบัตรรัฐบาลไทยหรือพันธบัตรของ ปตท. หรือหุ้นกู้ ปตท. มา เพื่อเป็นหลักประกันการปฏิบัติตามสัญญาหรือใบสั่งจ้าง ในอัตราร้อยละ 5 ของสัญญาหรือใบสั่งจ้าง (หากมีเศษสตางค์ให้ปัดขึ้น) นั้น หลักประกันการปฏิบัติตามสัญญาหรือใบสั่งจ้างดังกล่าว ปตท. จะคืนให้เมื่อผู้รับจ้าง พ้นจากข้อผูกพันตามสัญญาหรือใบสั่งจ้าง นั้นแล้ว

12.3 ผู้รับจ้างจะต้องเป็นผู้รับภาระในเรื่องอากรแสตมป์ที่จะใช้ปิดสัญญาจ้างหรือใบสั่งจ้าง ตามอัตราที่ประมวลรัษฎากรกำหนด

12.4 ในกรณีผู้ที่ได้รับการคัดเลือกแล้วไม่ยอมไปทำสัญญาภายในระยะเวลาที่ ปตท. กำหนด หรือผู้รับจ้างไม่ปฏิบัติตามสัญญานั้นโดยไม่มีเหตุผลอันสมควร ปตท. จะพิจารณาให้เป็นผู้ทิ้งงานและตัดออกจากทะเบียนผู้ค้าของ ปตท.

13. การจ่ายเงินล่วงหน้า

ไม่มีการจ่ายเงินล่วงหน้า

14. การปฏิบัติตามแนวทางการปฏิบัติอย่างยั่งยืนของผู้ค้ากลุ่ม ปตท. (PTT Supplier Sustainable Code of Conduct) (กรณีสัญญา/หนังสือข้อตกลงที่มีวงเงินตั้งแต่ 2 ล้านบาทขึ้นไป)

ผู้ยื่นข้อเสนอที่ ปตท. ตกลงในการจ้าง จะต้องยอมรับและปฏิบัติตามแนวทางการปฏิบัติอย่างยั่งยืนของผู้ค้า ปตท. (PTT Supplier Sustainable Code of Conduct) โดย ปตท. ขอสงวนสิทธิ์ในการเข้าตรวจสอบการดำเนินการตามแนวทางดังกล่าว

ผู้ค้าที่จะร่วมดำเนินธุรกิจกับ ปตท. จะต้องปฏิบัติตามแนวทางการปฏิบัติอย่างยั่งยืนของผู้ค้ากลุ่ม ปตท. และเงื่อนไข ดังต่อไปนี้

14.1 ปฏิบัติตามกฎหมายและกฎระเบียบต่างๆ ที่เกี่ยวข้องอย่างเคร่งครัด ครอบคลุมด้านจริยธรรมทางธุรกิจ ความรับผิดชอบต่อสังคม ความปลอดภัย และสิ่งแวดล้อม เช่น กฎหมายคุ้มครองแรงงาน กฎหมายว่าด้วยความปลอดภัย อาชีวอนามัย และสิ่งแวดล้อม รวมถึงต้องดำเนินงานด้วยความมีจริยธรรม โปร่งใส และไม่ทำการใดๆ อันเป็นการทุจริตคอร์รัปชั่น ติดหรือรับสินบน การกระทำอันก่อให้เกิดความขัดแย้งทางผลประโยชน์และ/หรือผลประโยชน์ทับซ้อน และการละเมิดทรัพย์สินทางปัญญา

14.2 ผู้ค้าจะต้องมีคุณสมบัติสอดคล้องกับ เกณฑ์บังคับหลัก ด้านจริยธรรมทางธุรกิจ ความรับผิดชอบต่อสังคม ความปลอดภัย และสิ่งแวดล้อม (ESG Interception Criteria) 7 ข้อ ดังนี้

(1) ไม่อยู่ในบัญชีรายชื่อของปตท. ว่าเป็นบุคคล นิติบุคคล หรือสถานประกอบการที่เกี่ยวข้องกับการทุจริต ติดสินบน หรือมีความขัดแย้งทางผลประโยชน์กับ ปตท. ณ เวลาที่ยื่นซอง

(2) มีใบอนุญาตทำงานที่เกี่ยวข้องตามที่กฎหมายกำหนด

(3) ไม่ถูกตัดสินให้มีความผิดในชั้นศาลด้านการเงิน สิ่งแวดล้อม ความปลอดภัย แรงงาน หรือ อยู่ในบัญชีรายชื่อบุคคล นิติบุคคล หรือสถานประกอบการที่ไม่ถูกต้องตามกฎหมายไทย ภายในระยะเวลา 3 ปี ก่อนการยื่นซอง

(4) มีนโยบายของบริษัทที่จะไม่จ้างแรงงานเด็กอายุต่ำกว่า 15 ปี

(5) มีนโยบายของบริษัทที่จะจ่ายค่าตอบแทนแก่ลูกจ้างไม่น้อยกว่าอัตราค่าจ้างขั้นต่ำที่กฎหมายกำหนด และไม่

บังคับให้ลูกจ้างทำงานนานเกินกว่ากฎหมายกำหนด

(6) มีระบบบริหารจัดการอาชีวอนามัยและความปลอดภัยในที่ทำงานตามที่กฎหมายกำหนด และดูแลให้ลูกจ้างปฏิบัติงานด้วยความปลอดภัย ไม่ก่อให้เกิดอันตราย

(7) มีระบบบริหารจัดการพื้นที่ปฏิบัติงาน และพื้นที่ที่มีความเสี่ยงที่อาจจะได้รับผลกระทบจากการดำเนินงานไม่ให้มีความเสี่ยงเชิงนิเวศ (Environmental Liability) (เช่น การปนเปื้อนหรือรั่วไหลของสารอันตรายในดินและน้ำใต้ดิน)

15. การประเมินผลการปฏิบัติงานของผู้ค้า

15.1 ปตท.จะทำการประเมินผลการปฏิบัติงานของผู้ค้าหลังส่งมอบงานทุกงวดงาน

15.2 ปตท.ขอสงวนสิทธิ์ที่จะใช้ผลประเมินการปฏิบัติงานของผู้ค้าเพื่อประกอบในการพิจารณาคุณสมบัติของผู้ยื่นข้อเสนอในครั้งถัดไป

15.3 สำหรับผู้ค้าที่ได้รับการอนุมัติให้ขึ้นกลุ่มงานในทะเบียนผู้ค้า ปตท. (PTT AVL) หากผู้ค้าได้รับการประเมินผลการปฏิบัติงานภายใต้กลุ่มงานที่ผู้ค้าได้รับการอนุมัติเป็นเกรด “D” ปตท. ขอสงวนสิทธิ์ตัดรายชื่อผู้ค้าออกจากกลุ่มงานดังกล่าว และผู้ค้าจะไม่มีสิทธิยื่นขอขึ้นทะเบียนผู้ค้ากับ ปตท. ในกลุ่มงานนั้นเป็นเวลาอย่างน้อย 3 ปี นับถัดจากวันที่ถูกตัดออก

15.4 กรณีที่ผู้ค้ามีข้อสงสัยผลประเมินการปฏิบัติงานของผู้ค้า ให้ผู้ค้าทำหนังสือพร้อมแนบสำเนาใบสั่ง/สัญญาและผลการปฏิบัติงาน ส่งถึงหน่วยงานจัดหาพัสดุเจ้าของเรื่อง เพื่อขอให้ชี้แจงข้อสงสัยของการประเมินผลการปฏิบัติงานของผู้ค้าได้ โดยสามารถตรวจสอบผลการปฏิบัติงาน ผ่านช่องทาง https://pttvm.pttplc.com

16. ข้อกำหนดด้านเทคนิค/ขอบเขตงาน

ตามเอกสารแนบ TOR Form_ข้อ_16

17. <u>ข้อกำหนดอื่น ๆ</u>

ความรับผิดชอบไม่ว่ากรณีใดๆ ผู้ขายจะยกข้ออ้างถึงการที่ตนไม่ทราบข้อเท็จจริงต่างๆหรือข้อมูลที่กล่าวมาข้างต้นเพื่อประโยชน์ใดๆของตนไม่ได้

1. การขนส่งวัสดุ,สารเคมี,เครื่องจักรอุปกรณ์ และสารต่าง ๆ รวมทั้งยานพาหนะขนส่ง จำต้องคำนึงถึงการพิทักษ์รักษาสิ่งแวดล้อมโดยจะต้องไม่ก่อให้เกิดการหกล้น,รั่วไหล,ทิ้งเรี่ยราดตามรายทางหรือ ปล่อยไอสาร,ไอเสีย,สารพิษ เกินกว่ามาตรฐานที่กฎหมายกำหนด

2. ผลิตภัณฑ์ที่ส่งมอบที่จะต้องนำเข้ามาใช้ใน โรงแยกก๊าซธรรมชาติระยอง หรือภายในพื้นที่ ปตท. หรืออยู่ภายใต้การควบคุมการปฏิบัติงาน (Operational Control) ของ ปตท. จะต้องไม่มีองค์ประกอบของแอสเบสตอส (Asbestos) หรือสารทำลายชั้นโอโซนของบรรยากาศตามประกาศ EPA: THE CLEAN AIR ACT SEC.602

3. การขนถ่าย, การเคลื่อนย้าย, การจัดเก็บ, การจดบันทึก และการกำจัดของเสียที่เกิดจากกิจกรรมใดๆภายใต้การจัดจ้างของโรงแยกก๊าซธรรมชาติระยอง ต้องอ้างอิงขั้นตอนการปฏิบัติตาม QSHEP-GSP-19-022 การควบคุมกากของเสียจากกระบวนการผลิต การซ่อมบำรุง และของเสียอันตรายสำนักงาน ตามข้อกำหนด ISO 14001 ในเรื่องของการควบคุมการปฏิบัติงาน (Operational Control)

4. ผลิตภัณฑ์ที่ส่งมอบ เพื่อใช้งานในโรงแยกก๊าซธรรมชาติระยอง ที่เกี่ยวข้องกับการใช้พลังงานอย่างมีนัยสำคัญ เช่น คอมเพรสเซอร์ของระบบปรับอากาศ หรืออุปกรณ์อื่นๆ จะต้องได้รับการรับรองการประหยัดพลังงานจากผู้ผลิต โดยมีใบ Certificate หรือหนังสือรับรองตามมาตรฐานอุตสาหกรรมหรือเทียบเท่า

5. ผู้ส่งมอบต้องส่งเสริมการแสดงความรับผิดชอบด้านการอนุรักษ์พลังงาน รวมถึงให้ความร่วมมือกับ ปตท. ในการใช้พลังงานอย่างมีประสิทธิภาพ

6. ในการจัดซื้อที่เกี่ยวข้องกับระบบการจัดการพลังงานต้องจัดทำรายงานสรุปผลการประเมินการใช้พลังงานส่งมอบพร้อมกันเพื่อประกอบการตรวจรับ

7. เพื่อให้การดำเนินการจัดหาเป็นไปตามมาตรฐาน มรท.8001 ปตท. สงวนสิทธิ์ในการพิจารณาคัดเลือกผู้ค้าในกลุ่มที่ได้รับการรับรองมาตรฐาน มรท.8001 หรือผู้ค้าที่แสดงความมุ่งมั่นในการดำเนินงานตามมาตรฐาน มรท.8001 โดยมีหลักเกณฑ์ในการแสดงความมุ่งมั่นดังต่อไปนี้

7.1 ผู้ส่งมอบ/ผู้รับเหมาช่วงต้องไม่สนับสนุนให้มีการใช้แรงงานบังคับทุกรูปแบบ

7.2 ผู้ส่งมอบ/ผู้รับเหมาช่วงต้องจ่ายค่าจ้างและค่าตอบแทนการทำงานไม่น้อยกว่าที่กฎหมายกำหนด

7.3 ผู้ส่งมอบ/ผู้รับเหมาช่วงต้องไม่กระทำการหรือสนับสนุนให้มีการเลือกปฏิบัติให้มีการจ้างงาน จ่ายค่าจ้างการให้สวัสดิการ เนื่องด้วยความแตกต่างเรื่องเชื้อชาติ เพศ ศาสนา การตั้งครรภ์ สถานภาพการสมรส การ เป็นสมาชิกสหภาพ และไม่กีดกันการทำงานเนื่องมาจากการพิการหรือติดเชื้อเอชไอวี

7.4 ผู้ส่งมอบ/ผู้รับเหมาช่วงต้องไม่กระทำการหรือสนับสนุนให้มีการลงโทษทางร่างกาย จิตใจ หรือกระทำการบังคับขู่เข็ญทำร้ายลูกจ้าง รวมถึงมีมาตรการป้องกันไม่ให้เกิดมีการล่วงละเมิดทางเพศ โดยการแสดงออกด้วยคำพูด ท่าทางการสัมผัสทางกาย หรือวิธีการอื่นใด และไม่ให้มีการลงโทษลูกจ้างโดยวิธีการหักเงินเดือนหรือลดค่าจ้าง

7.5 ผู้ส่งมอบ/ผู้รับเหมาช่วงต้องไม่ให้ลูกจ้างหญิงทำงานที่เป็นอันตรายต่อสุขภาพและร่างกายตามที่กฎหมายกำหนด

7.6 ผู้ส่งมอบ/ผู้รับเหมาช่วงต้องมีมาตรการด้านความปลอดภัยอาชีวอนามัย และสภาพแวดล้อมในการทำงานเพื่อให้พนักงานปฏิบัติงานอย่างปลอดภัย และจัดให้มีสวัสดิการพนักงานตามที่กฎหมายแรงงานกำหนดไว้

7.7 บริษัท ปตท. จำกัด (มหาชน) ไม่มีนโยบายสนับสนุนให้ใช้แรงงานเด็กที่มีอายุต่ำกว่า 18 ปี

7.8 ผู้ส่งมอบ/ผู้รับเหมาช่วงต้องปฏิบัติตาม พระราชบัญญัติคุ้มครองแรงงาน 2541 และฉบับที่แก้ไขเพิ่มเติม รวมถึงกฎหมายอื่นๆ ที่เกี่ยวข้องเพื่อให้สอดคล้องกับข้อกำหนดด้านมาตรฐานแรงงานไทย

7.9 ผู้ส่งมอบ/ผู้รับเหมาจะแจ้งให้ โรงแยกก๊าซธรรมชาติ บริษัท ปตท.จำกัด (มหาชน) ทราบกรณีมีความสัมพันธ์ทางธุรกิจกับผู้ส่งมอบรายอื่นในกิจกรรมที่ต้องรับผิดชอบต่อ โรงแยกก๊าซธรรมชาติ บริษัท ปตท.จำกัด (มหาชน)

8. โรงแยกก๊าซธรรมชาติระยองมีระบบการจัดการวัดผลผู้ค้าหลังการส่งมอบ หากผู้ค้ารายใดได้รับผลการวัดผลต่ำกว่าที่ตั้งไว้ โรงแยกก๊าซธรรมชาติระยองจะทำหนังสือเตือนให้ผู้ค้าทราบ และจะรวบรวมไว้เป็นข้อมูลในการประเมินผลผู้ค้าประจำปี ผู้ค้าที่ไม่ผ่านผลการประเมินผู้ค้าประจำปี จะถูกยกเลิกออกจากทะเบียนผู้ค้าของโรงแยกก๊าซธรรมชาติระยอง

9. ผู้ส่งมอบ/ผู้รับเหมาจะต้องปฏิบัติตามประกาศกรมสวัสดิการและคุ้มครองแรงงานเกี่ยวกับการอบรมความปลอดภัย โดยจะต้องจัดเตรียมเอกสารหลักฐานการรับรองการผ่านการอบรมหลักสูตรด้านความปลอดภัย อาชีวอนามัยและสภาพแวดล้อมในการทำงานรวมเป็นระยะเวลาทั้งสิ้น 6 ชั่วโมง สำหรับผู้ที่จะเข้ามาปฏิบัติงานในโรงแยกก๊าซฯ จ.ระยอง โดยให้ทำการส่งเอกสารการรับรองดังกล่าวให้แก่ผู้ควบคุมงานหรือผู้ประสานงานของท่านเพื่อนำข้อมูลการรับรองดังกล่าวบันทึกลงในระบบ Access Control ตั้งแต่วันที่ 1 กันยายน 2556 เป็นต้นไป หากผู้ส่งมอบ/ผู้รับเหมาไม่ปฏิบัติตามให้อยู่ในดุลพินิจของ ปตท. ในการพิจารณาให้เข้าปฏิบัติงานในโรงแยกก๊าซฯ จ.ระยอง เป็นแต่ละกรณีไป

18. <u>กฎความปลอดภัยทั่วไป (อ้างอิงตาม QSHEP-GSP-11-006)</u>

ข้อกำหนดที่ต้องปฏิบัติ สำหรับพนักงาน และผู้ปฏิบัติงานในพื้นที่รับผิดชอบของ โรงแยกก๊าซธรรมชาติระยอง หรือภายในพื้นที่ ปตท. หรืออยู่ภายใต้การควบคุมการปฏิบัติงาน (Operational Control) ของ ปตท.

ระบบมาตรฐานที่เกี่ยวข้อง

☐ Quality	■ Safety	☐ Health	☐ Environment	☐ Lab	☐ Energy

1. การปฏิบัติงานต้องปฏิบัติตามคู่มือ และมาตรฐาน ไม่กระทำใดๆที่เสี่ยงต่ออันตราย
2. ต้องตรวจสอบสภาพความปลอดภัย ในบริเวณที่ปฏิบัติงานก่อนลงมือทำงานทุกครั้ง
3. รายงานผู้บังคับบัญชาหรือผู้ควบคุมงานทันที เมื่อเกิดอุบัติเหตุ, เหตุการณ์เกือบเกิดเป็นอุบัติเหตุ (Near miss), และ เมื่อพบเห็นการ

กระทำ หรือสภาพการณ์ที่อาจก่อให้เกิด อุบัติเหตุ

4. สถานที่ทำงาน ต้องไม่มีสิ่งของเหลือใช้หรือเกินความจำเป็น และจัดสิ่งที่มีอยู่ให้เป็นระเบียบเรียบร้อย
5. เครื่องมือ, เครื่องจักร, อุปกรณ์ และยานพาหนะต้องได้รับการตรวจสอบตามวาระ และใช้ให้เหมาะสมกับงานอย่างถูกวิธี และเมื่อเกิดการชำรุดเสียหายให้รายงานผู้บังคับบัญชาหรือผู้ควบคุมงานทราบทันที
6. การใช้, ปรับแต่ง, เปลี่ยนแปลง หรือซ่อมแซมอุปกรณ์ใด ๆ ต้องกระทำโดยผู้มีหน้าที่เท่านั้น
7. กรณีที่ปฏิบัติงานในเขตโรงงาน ต้องแต่งกายรัดกุมด้วยเสื้อแขนยาว และต้องใส่อุปกรณ์ป้องกันภัยส่วนบุคคลพื้นฐาน อันได้แก่ หมวกนิรภัย แว่นตานิรภัย และรองเท้านิรภัย รวมทั้งอุปกรณ์ ป้องกันภัยส่วนบุคคลอื่นๆตามลักษณะงานที่ได้รับมาตรฐานตามที่กฎหมายกำหนด ทั้งนี้กรณีที่เข้าเขตอาคารควบคุมการผลิต (CCR) ต้องสวมใส่เสื้อแขนยาว รวมถึงกางเกงขายาวด้วย
8. ห้ามเล่นการพนัน ห้ามดื่มสุรา หรือเสพของมึนเมา หรืออยู่ในอาการมึนเมา และห้ามหยอกล้อเล่นกันตลอดเวลาที่ปฏิบัติงานในเขตโรงงาน
9. ห้ามลักลอบนำเข้า หรือเสพยาเสพติดทุกชนิดที่ผิดกฎหมาย ในทุกพื้นที่ของ ปตท.
10. หากมีการลักลอบนำทรัพย์สิน หรือสิ่งของทุกชนิดของปตท.ออกนอกพื้นที่โดยไม่ได้รับอนุญาต ผู้ลักลอบจะต้องถูกส่งดำเนินคดีตามกฎหมาย
11. ห้ามสูบบุหรี่ หรือ กระทำการใดๆที่ก่อให้เกิดประกายไฟ ในเขตโรงงาน นอกบริเวณอาคาร และนอกพื้นที่ที่ได้รับอนุญาต
12. ปฏิบัติตามแผนฉุกเฉิน, กฎระเบียบ ,เครื่องหมายป้ายเตือน และคำแนะนำอย่างเคร่งครัด
13. การนำยานพาหนะ, เครื่องยนต์, อุปกรณ์ไฟฟ้า, กล้องถ่ายรูป และอุปกรณ์ที่อาจก่อให้เกิดประกายไฟเข้าในเขตโรงงาน ต้องได้รับการตรวจสภาพ และออกบัตรอนุญาตก่อนทุกครั้ง
14. การกำหนดความเร็วยานพาหนะ ภายในเขตโรงงานไม่เกิน 20 กม./ชม. และนอกเขตโรงงานไม่เกิน 40 กม./ชม.
15. พนักงานใหม่ ผู้รับเหมาประจำ และผู้รับเหมาชั่วคราวต้องเข้ารับการอบรมกฎความปลอดภัยนี้ก่อนเข้าปฏิบัติงานภายในเขตโรงงาน และต้องได้รับการทบทวนอย่างน้อยปีละ 1 ครั้ง หรือทุก 6 เดือน

2.11 ผู้เสนอราคาจะต้องเป็นบริษัทเจ้าของผลิตภัณฑ์ Allen Bradley **หรือ** บริษัทที่เป็นตัวแทนจำหน่ายผลิตภัณฑ์ Allen Bradley ที่ได้รับการแต่งตั้งโดยตรง **หรือ** บริษัทที่เป็น SI (System Integrated) ที่ได้รับการรับรองจากบริษัท Rockwell Automation Thai Co.,Ltd. โดยใบรับรองต้องมีอายุไม่เกิน 4 ปี (นับตั้งแต่ พ.ศ. 2562 หรือ ค.ศ. 2019)

2.12 ผู้เสนอราคาจะต้องมีประสบการณ์ (งานแล้วเสร็จ)ในงาน Project เกี่ยวกับผลิตภัณฑ์ของ Allen-bradley ในส่วนของ PLC และ HMI รุ่น PanelViewPlus โดยจะต้องเป็นงานในส่วนของการ Design และ Engineering และ Installation ของโรงแยกก๊าซ หรือ โรงกลั่นน้ำมัน หรือ โรงงานปิโตรเคมี หรือ โรงงานอุตสาหกรรม มูลค่างานอย่างน้อย 1 ล้านบาท ในระยะเวลา 4 ปีย้อนหลัง (พ.ศ. 2562 - พ.ศ. 2565) เป็นจำนวน 3 PO โดยต้องยื่นหลักฐานดังต่อไปนี้

2.12.1 ใบสั่งจ้าง (PO) โดยต้องมีมูลค่าตั้งแต่ 1 ล้านบาทขึ้นไป อย่างน้อย 3 ใบ

2.12.2 หนังสือส่งมอบงาน ของเอกสารในข้อกำหนดข้อที่ 2.12.1

2.12.3 หนังสือชี้แจงรายละเอียดของงานโดยละเอียด หรือ รายงานปฏิบัติงานประกอบรูปถ่าย (Final report) ของเอกสารในข้อกำหนดข้อที่ 2.12.1

2.13 กรณีที่ผู้เสนอราคาเคยมีผลงานตามข้อ 2.12 มาก่อน แต่เป็นการดำเนินธุรกิจประเภทรับจ้างช่วง (ไม่เคยรับงานโดยตรง) อยู่ในดุลยพินิจของ ปตท. ที่จะให้เสนอราคาหรือพิจารณาการเสนอราคาหรือไม่ก็ได้ โดยผู้ใดไม่มีสิทธิ์ฟ้องร้องเรียกค่าเสียหายใด ๆ ทั้งสิ้น

3.2 ซองเอกสารเทคนิค

3.2.1 เอกสารรับรองการเป็น Authorized Distributor หรือ เอกสารรับรองการเป็นบริษัท SI จากบริษัท Rockwell Automation Thai Co.Ltd. โดยต้องมีอายุไม่เกิน 4 ปีเท่านั้น (นับตั้งแต่ พ.ศ. 2562 หรือ ค.ศ. 2019) ตามข้อกำหนดข้อที่ 2.11

3.2.2 เอกสารรับรองการผ่านงาน ผู้เสนอราคาต้องยื่นเอกสารประกอบไปด้วยเอกสารตามข้อกำหนดข้อที่ 2.12 **หากผู้เสนอราคาไม่สามารถส่งเอกสารได้ครบตามข้อ 2.12 ทาง ปตท. ขอพิจารณาให้ผู้เสนอราคาราย นั้น "ไม่ผ่านเทคนิค" และไม่พิจารณาการเสนอราคาของผู้เสนอราคารายนั้น**

3.2.3 เนื่องจาก ปตท. ต้องการจ้างบริษัท และบุคคลากรที่มีประสบการณ์และความชำนาญในงาน ผู้เสนอราคาจะต้องแสดงหลักฐานที่เกี่ยวข้อง ที่สามารถสอบกลับเพื่อยืนยันได้ว่า บุคคลหรือบุคลากรของ Subcontractor ที่ผู้เสนอราคาว่าจ้างมา ที่จะมาปฏิบัติงานมีประสบการณ์และความชำนาญเพียงพอ รวมถึงผู้เสนอราคาต้องมีกำลังคนที่เหมาะสม เพียงพอในการปฏิบัติงานให้สำเร็จตามข้อกำหนดของคุณภาพและระยะเวลาที่กำหนดไว้ในสัญญาจ้าง

3.2.3.1. PROJECT ORGANIZE CHART โดยจะต้องระบุชื่อ รูปถ่าย ตำแหน่ง เบอร์ติดต่อ ดังต่อไปนี้

3.2.3.1.1. PROJECT ENGINEER หรือ PLANNER อย่างน้อย 1 คน จะต้องเป็นพนักงานของบริษัทผู้เสนอราคาเท่านั้น ซึ่งจะต้องมีความสามารถในการดูแผนงานในภาพรวม มองปัญหาล่วงหน้า และแก้ไขปัญหาเพื่อให้งานแล้วเสร็จตามแผนงานที่กำหนด โดยจะต้องเคยผ่านงาน Instrument มาอย่างน้อย 10 ปีโดยส่งหลักฐานการผ่านงานเป็นรูปถ่ายพร้อมรายงานประกอบ

3.2.3.1.2. PLC Programmer อย่างน้อย 1 คน โดยจะต้องเป็นพนักงานของบริษัทที่ได้รับรองการเป็น Authorized Distributor หรือ เอกสารรับรองการเป็นบริษัท SI จากบริษัท Rockwell Automation Thai Co.Ltd. โดยต้องมีอายุไม่เกิน 4 ปีเท่านั้น (นับตั้งแต่ พ.ศ. 2562 หรือ ค.ศ. 2019) ตามข้อกำหนดข้อที่ 2.11

3.2.3.1.3. SUPERVISOR/ FOREMAN อย่างน้อย 1 คน โดยจะต้องเป็นพนักงานของบริษัทผู้เสนอราคาเท่านั้น ซึ่งจะต้องมีความสามารถในการดูแล ติดตามหน้างาน แก้ปัญหาหน้างาน และมีความรู้ในงานที่เกี่ยวข้องรวมถึงแก้ไขปัญหาหน้างานตามข้อเสนอแนะของผู้ควบคุมงาน ปตท. โดยจะต้องเคยผ่านงาน Instrument มาอย่างน้อย 5 ปี โดยส่งหลักฐานการผ่านงานเป็นรูปถ่ายพร้อม

รายงานประกอบ ซึ่งทาง ปตท. ขอสงวนสิทธิ์ผู้เข้ามาทำงานต้องผ่านการสอบสัมภาษณ์งานจากทางผู้ควบคุมงาน ปตท. เท่านั้น

3.2.3.1.4. TECHNICIAN หรือ MANPOWER ที่จะใช้ในการดำเนินงาน (รวมทั้งของผู้รับจ้าง และผู้รับจ้างช่วง)

3.2.3.1.5. **เจ้าหน้าที่ความปลอดภัย** อย่างน้อย 1 คน สำหรับควบคุมการปฏิบัติงานของผู้ปฏิบัติงานให้อยู่ในความปลอดภัยและอยู่ในกฎความปลอดภัยของโรงแยกก๊าซธรรมชาติระยอง

3.2.3.2. RESUME ของบุคคลที่ปรากฏชื่อตามข้อ 3.2.3.1 ทั้งหมด เพื่อพิจารณาความเหมาะสมของประสบการณ์และความชำนาญ ของบุคคลในแต่ละตำแหน่ง รายละเอียดดังนี้

3.2.3.2.1. ประวัติโดยย่อพร้อมรูปถ่าย

3.2.3.2.2. เอกสารแสดงการผ่านอบรมเกี่ยวกับงาน instrument หรือเอกสารแสดงประวัติการผ่านงานจากโรงแยกก๊าซ, โรงกลั่นน้ำมัน หรือโรงงานปิโตรเคมี เพื่อสอบกลับว่าบุคคลดังกล่าวมีประสบการณ์เคยผ่านงานจริง โดยส่งหลักฐานการผ่านงานเป็นรูปถ่ายพร้อมรายงานประกอบ

3.2.3.2.3. เอกสารแสดงการผ่านอบรมเกี่ยวกับงานระบบ Automation ของบริษัท Rockwell Automation เท่านั้น และเอกสารแสดงประวัติการผ่านงานจากโรงแยกก๊าซ, โรงกลั่นน้ำมัน หรือโรงงานปิโตรเคมี เพื่อสอบกลับว่าบุคคลดังกล่าวมีประสบการณ์เคยผ่านงานจริง

หากทาง ปตท. เห็นว่าบุคคลที่ผู้เสนอราคามานั้น มีประสบการณ์หรือความชำนาญไม่เพียงพอ ขอพิจารณาให้ผู้เสนอราคารายนั้น “ไม่ผ่านเทคนิค” และไม่พิจารณาการเสนอราคาของผู้เสนอราคารายนั้น

3.2.3.2.4. เอกสารยืนยันว่า ผู้เสนอราคาจะว่าจ้างบุคคลตามรายชื่อที่เสนอมาตามข้อ 3.2.3.1 มาปฏิบัติงานจริงหากได้งาน หากผู้เสนอราคาไม่สามารถส่งเอกสารยืนยันผู้เข้ามาปฏิบัติงานได้ ทาง ปตท. ถือว่าผู้เสนอราคาไม่มีความพร้อมในการปฏิบัติงาน ขอพิจารณาให้ผู้เสนอราคารายนั้น “ไม่ผ่านเทคนิค” และไม่พิจารณาการเสนอราคาของผู้เสนอราคารายนั้น

หมายเหตุ: เอกสารทุกรายการผู้เสนอราคาต้องยื่นพร้อมกันในวันยื่นซองเท่านั้น หากเอกสารไม่ครบจะถือว่าการเสนอราคาของผู้เสนอราคารายนั้นเป็นโมฆะ รวมถึงหากทาง ปตท. พิจารณาถึงคุณสมบัติของผู้เสนอราคาและประสบการณ์

ของ PROJECT ENGINEER หรือ PLANNER ไม่เพียงพอ ทางปตท. ขอสงวนสิทธิที่จะพิจารณา "ไม่ผ่านเทคนิค" และจะไม่พิจารณาการเสนอราคาของผู้เสนอราคารายนั้นโดยผู้เสนอราคาไม่มีสิทธิ์ฟ้องร้องเรียกค่าเสียหายใด ๆ ทั้งสิ้น

<u>หมายเหตุ:</u> หากผู้เสนอราคาได้รับการว่าจ้าง แรงงาน และเครื่องมือที่แสดงในเอกสารการเสนอราคาจะถือเป็นข้อผูกพันในสัญญา ผู้เสนอราคาต้องจัดหามาใช้ในงานจริง จะอ้างว่าไม่มีไม่ได้ หาก ปตท. พิจารณาว่า แรงงานหรืออุปกรณ์ไม่มีความพร้อมและเพียงพอต่อการปฏิบัติงานให้มีคุณภาพ ทันเวลาและปลอดภัย ทาง ปตท. จะพิจารณาจัดหาด้วยตัวเอง ซึ่งทางผู้เสนอราคาจะต้องรับผิดชอบค่าใช้จ่ายดังกล่าว โดยผู้เสนอราคาไม่มีสิทธิฟ้องร้องกับทาง ปตท.

16. ข้อกำหนดด้านเทคนิค/ขอบเขตงาน

Scope of supply

1. ผู้รับจ้างจะต้องจัดหา Cable รายละเอียด ดังต่อไปนี้
   1.1. **Instrument Cable** โดยมี specification อ้างอิงมาตรฐานตาม “เอกสารแนบ_04_ES-60.10 Specification for Instrumentation Cables” ตามรูปที่ 1

Item	สถานที่ใช้งาน	Specification	ความยาวสาย
1	สายสำหรับทำการ wiring ภายในตู้ Fire & Gas Tank GSP3	Type: Single core Size: 1.5 mm^2	100 m.
2	สายสัญญาณ valve 714-HV-041 จากตู้ Fire & Gas GSP3 มายัง Fire & Gas Tank GSP3, สายจาก Junction box 31:JGDi-01 (40P) และ 31-JGDi-02 (60P) ไปยัง limit switch (Status valve), Push button (OPEN, CLOSE)	Type: 2 pair Size: 1.5 mm^2 Color: Blue	700 เมตร
3	สายจาก JB: 31:JGS-01 ไปยัง Solenoid valve	Type: 1 pair Size: 2.5 mm^2 Color: Black	400 เมตร

ตารางที่ 1 รายการ instrument cable ที่ต้องจัดหา

6.1.3 Signal Cables for Fire and Gas Detection Service And Plant Communication

Cables for low level 4-20 mA signals to/from flame and gas detectors, mA level signals from smoke detectors, manual break-glass stations, fire protection service field transmitters, electronic level binary status signals for fire alarms, telephones, loudspeakers, visual warning lights including inter fire and gas panel signals and inter communication panel signals shall be of the type described in this section.

Cables shall be 300/500 V comply to

STANDARD APPLICABLE

BS 5308-1	Design Guideline
BS 6234	Specification for polyethylene insulation and sheath of electric cable
IEC 60332-1	Flame Retardant
IEC 60332-3C	Fire Retardant on Bunched Cables
BS1442	Specification for Galvanized mild steel wire for Armouring Cables
IEC 60754-1, 2	Halogen free properties
IEC 61034-1,2	Low smoke emission

Detailed specification shall be as below:

Conductors	Anneal Copper Wires according to Class 1 or 2 or 5 of BS 602281.0 or 1.5 mm^2.0.5 mm^2 cores may be used for telephones.
Fire barrier	Mica/glass tape
Insulation	XLPE in accordance with IEC 60502
Pairs	Twisted
Identification pairs	Black, white numbered
Assembly	Concentric Layers
Overall Screen	Aluminums / Polyester tape 0.024 mm in electrical contact with tinned annealed copper wires of a total section of 0.5 mm^2 polyester tape 0.023 mm
Bedding	LSOH compound
Armour	Galvanized Steel wire comply with BS 1442
Outer Sheath	LSOH compound, colour is blue for I.S. cables, black otherwise.
Core Identification	Number Black / White for pairs. Number Black / White / Red for triples.

รูปที่ 1 Instrument cable specification ตาม PTT ES 60.10

1.2. Cable ที่จะนำมาใช้กับระบบจะต้องเป็นยี่ห้อที่มีใน Vendor list ของทางโรงแยกก๊าซธรรมชาติระยองเท่านั้น ตาม <u>**“เอกสารแนบ_01_PTT's approved vendor List_GSP Rev_13”**</u>

5.26. Instrument Cable

- Hitachi Cable	Japan
- Thai Yazaki Electric Wire Co., Ltd.	Thailand
- MCI Draka	Thailand
- Bangkok Cable	Thailand
- Wilson	Thailand
- Phelps Dodge	Thailand
- LAPP Cable*	Italy

รูปที่ 2 ยี่ห้อ Instrument cable ตาม Vendor list ของโรงแยกก๊าซธรรมชาติระยอง

2. ผู้รับจ้างจะต้องจัดหา Cable Grand โดยมี specification เป็น Ex d, Material: Brass, with Shroud หรืออุปกรณ์อื่นใด ให้เพียงพอต่องานติดตั้ง ซึ่งอุปกรณ์ดังกล่าวจะต้องเป็นยี่ห้อที่มีใน Vendor list ของทางโรงแยกก๊าซธรรมชาติระยองเท่านั้น ตาม <u>**“เอกสารแนบ_01_PTT's approved vendor List_GSP Rev_13”**</u>

9.7. Cable Gland

- Hawke	International
- CMP	U.K.
- Peppers	U.K.

รูปที่ 3 ยี่ห้อ Cable gland ตาม Vendor list ของโรงแยกก๊าซธรรมชาติระยอง

3. ผู้รับจ้างจะต้องจัดหา Limit switch Specification: Proximitor, Ex i ของอุปกรณ์ ให้สามารถใช้งานได้ตาม Function ดังต่อไปนี้

3.1. 705-GSO-5505 (Status: OPEN)	จำนวน	1	ตัว
3.2. 705-GSC-5505 (Status: CLOSE)	จำนวน	1	ตัว

4. ผู้รับจ้างจะต้องจัดหา Pressure Transmitter with display Specification: Ex i, Range: 0-10 Bar, Medium: water ของอุปกรณ์ ให้สามารถใช้งานได้ตาม Function โดยจะมีดังต่อไปนี้

   4.1. 705-GS-025 จำนวน 1 ตัว

5.10.1. Pressure Transmitter, Diff Pressure Transmitter, Temperature Transmitter

- Rosemount	International
- Yokogawa Electric Corp.	Japan

รูปที่ 4 ยี่ห้อ Pressure Transmitter ตาม Vendor list ของโรงแยกก๊าซธรรมชาติระยอง

5. ผู้รับจ้างจะต้องจัดหา Solenoid valve model: JBEF8327G042MS 24VDC, Ex i ยี่ห้อ ASCO ของอุปกรณ์ ดังต่อไปนี้

   5.1. 705-SOV-5505 จำนวน 1 ตัว

   5.2. 705-SOV-025 จำนวน 1 ตัว

6. ผู้รับจ้างจะต้องจัดหา Push button BOX Specification: 2 buttons, IP67, ขั้นต่ำเป็น Ex i ทั้งหมด, ของอุปกรณ์ดังต่อไปนี้

   Phase 1

   6.1. BOX: 705-HS-5505 จำนวน 1 box

   6.1.1. BUTTON: 705-HS-5505A (OPEN) ปุ่มเป็นสีแดง พร้อมตัวอักษร OPEN สีขาว จำนวน 1 button

   6.1.2. BUTTON: 705-HS-5505B (CLOSE) ปุ่มเป็นสีเขียว พร้อมตัวอักษร CLOSE สีขาว จำนวน 1 button

   6.2. BOX: 705-HS-025 จำนวน 1 box

   6.2.1. BUTTON: 705-HS-025A (OPEN) ปุ่มเป็นสีแดง พร้อมตัวอักษร OPEN สีขาว จำนวน 1 button

   6.2.2. BUTTON: 705-HS-025B (CLOSE) ปุ่มเป็นสีเขียว พร้อมตัวอักษร CLOSE สีขาว จำนวน 1 button

   6.3. BOX: HS-571 (714-HV-041) จำนวน 1 box

   6.3.1. BUTTON: 705-HS-571A (OPEN) ปุ่มเป็นสีแดง พร้อมตัวอักษร OPEN สีขาว จำนวน 1 button

   6.3.2. BUTTON: 705-HS-571B (CLOSE) ปุ่มเป็นสีเขียว พร้อมตัวอักษร CLOSE สีขาว จำนวน 1 button

Phase 2

6.4. BOX: Deluge valve Tank GSP3 จำนวน 11 box

6.4.1. BUTTON OPEN ปุ่มเป็นสีแดง พร้อมตัวอักษร OPEN สีขาว จำนวน 1 button

6.4.2. BUTTON CLOSE ปุ่มเป็นสีเขียว พร้อมตัวอักษร CLOSE สีขาว จำนวน 1 button

5.23. Push button, bulb, relay and accessories

-	Idec Izumi	Japan
-	Omron	Japan
-	Telemecanique	France
-	ABB	Europe

รูปที่ 5 ยี่ห้อ Push button ตาม Vendor list ของโรงแยกก๊าซธรรมชาติระยอง

4.23. Local Control Station

-	Idec Izumi Corp.	Japan
-	Mori Denki Electric	Japan
-	Togami Electric	Japan
-	O-Z/GEDNEY	U.S.A.
-	Crouse-Hinds	U.S.A.
-	Bartec	Germany
-	Warom	China

รูปที่ 6 ยี่ห้อ Push button BOX ตาม Vendor list ของโรงแยกก๊าซธรรมชาติระยอง

7. ผู้รับจ้างจะต้องจัดหาอุปกรณ์อื่น ๆ ที่จำเป็น เพื่อให้งานติดตั้งสามารถดำเนินการได้อย่างสมบูรณ์และเป็นไปตาม จะต้องเป็นไปตามมาตรฐาน PTT Engineering Standard หรือมาตรฐานสากลอื่น ๆ
8. **ผู้รับจ้างจะต้องจัดซื้ออุปกรณ์ที่นำมาใช้งานตามยี่ห้อที่มีใน Vendor list ของทางโรงแยกก๊าซธรรมชาติระยอง ตามเอกสารแนบ ชื่อ "เอกสารแนบ_01_PTT's approved vendor List_GSP Rev_13"**

Scope of work

ผู้รับจ้างต้องดำเนินงาน โดยมีรายละเอียดงาน ดังต่อไปนี้

1. ต้องส่งมอบเอกสารก่อนเริ่มดำเนินการติดตั้งระบบ ดังนี้
    - 1.1. Specification ของอุปกรณ์ที่ใช้ในระบบ
    - 1.2. Installation drawing
        - 1.2.1. Deluge valve ได้แก่ ตำแหน่งของ Solenoid valve, Limit switch box, Pressure transmitter
        - 1.2.2. การติดตั้ง Push button switch with stand
    - 1.3. Cable route plan
    - 1.4. Connection Diagram, Loop diagram
    - 1.5. Cabinet layout
2. งานติดตั้งอุปกรณ์ทั้งหมด จะต้องเป็นไปตามมาตรฐาน PTT Engineering Standard ดังต่อไปนี้
    - 2.1. Instrumentation General Specification: ES-60.01 (ตามเอกสารแนบ_02)
    - 2.2. Instrument Installation Specifications: ES-60.06 Rev0 (ตามเอกสารแนบ_03)
    - 2.3. Specifications for Instrumentation Cables: ES-60.10 Rev0 (ตามเอกสารแนบ_04)
    - 2.4. Specifications for Civil Work: ES-40_01 (ตามเอกสารแนบ_05)
    - 2.5. Electrical Standards: ES-70.01_Rev2 (ตามเอกสารแนบ_06)
    - 2.6. Electrical Cable Spec: ES-70.02.21_Rev1 (ตามเอกสารแนบ_07)
    - 2.7. Typical Installation detail drawing for Electrical and Instrument system
    - 2.8. มาตรฐานสากลอื่นๆ ที่เกี่ยวข้อง

Phase 1

3. ดำเนินการบนระบบ PLC Allen-Bradley ของ Rockwell Automation ดังต่อไปนี้
    - **3.1. Fire & Gas Tank GSP6**
        - 3.1.1. Convert program จาก ControlLogix L6 เป็น L7
        - 3.1.2. Revamp อุปกรณ์ตัวใหม่ ดังนี้
            - 3.1.2.1. Controller ControlLogix L73 จำนวน 2 ตัว
            - 3.1.2.2. Redundant module 1756-RM2 จำนวน 2 ตัว
            - 3.1.2.3. Communication module: ControlNet, Ethernet จำนวน 7 ตัว
            - 3.1.2.4. Power supply จำนวน 5 ตัว
            - 3.1.2.5. อุปกรณ์อื่น ๆ ที่จำเป็นต่อการทำงานของระบบ

3.2. Fire & Gas Tank GSP3

3.2.1. ย้าย loop จาก Fire & Gas GSP3 Tag: 714-HV-041

3.2.2. เพิ่ม Tag สำหรับ control deluge valve ใน Program

3.2.2.1. 714-HV-041 (ย้ายจาก Fire & Gas GSP3)

3.2.2.2. 705-HV-5505 (Emergency pipe leak)

3.2.2.3. 705-HV-025 (Emergency pipe leak)

3.2.3. ติดตั้ง Barrier จำนวน 8 ตัว

3.2.4. เก็บความเรียบร้อยของตู้ Fire & Gas tank GSP3 ดังนี้

3.2.4.1. ฝาตู้

3.2.4.2. เก็บสายภายในตู้

3.2.4.3. ใส่ Hot mark

3.3. HMI (PanelView Plus)

3.3.1. Renew Design zone HMI ของ Gas detector ให้สื่อกับการใช้งานมากขึ้น

3.3.2. เพิ่ม Tag สำหรับ control deluge valve

3.3.2.1. 714-HV-041 (ย้ายจาก Fire & Gas GSP3)

3.3.2.2. 705-HV-5505 (Emergency pipe leak)

3.3.2.3. 705-HV-025 (Emergency pipe leak)

4. ดำเนินการบนระบบ DCS ของ YOKOGAWA ดังต่อไปนี้

4.1. เพิ่ม Tag ใน DCS พร้อมทำ Soft link เพื่อ Control deluge valve ผ่าน Modbus

4.1.1. 714-HV-041

4.1.2. 705-HV-5505

4.1.3. 705-HV-025

4.2. แก้ไข Graphic บน DCS ในส่วนของ Valve ที่เพิ่มมาในข้อ 4.1

4.2.1. เขียนใหม่จำนวน 1 หน้า

5. ดำเนินการงานใน Field รายละเอียด ดังต่อไปนี้

5.1. ลากสายจาก Junction box บริเวณหน้างาน ไปยังอุปกรณ์ ดังนี้

5.1.1. Solenoid valve

5.1.2. Limit switch box

5.1.3. Push button switch box

5.2. Revamp Push button switch ของ Deluge valve ดังต่อไปนี้

5.2.1. 714-HS-571

5.2.2. 705-HS-5505

5.2.3. 705-HS-025

5.3. ติดตั้งอุปกรณ์หน้างาน ดังต่อไปนี้

5.3.1. Valve 714-HV-041

5.3.1.1. Push Button switch box (Replace)

5.3.1.2. อุปกรณ์อื่น ๆ ที่จำเป็นต่อการทำงานของระบบ

5.3.2. Valve 705-HV-5505

5.3.2.1. Push Button switch box (Replace)

5.3.2.2. Limit switch OPEN Status

5.3.2.3. Limit switch CLOSE status

5.3.2.4. Solenoid valve

5.3.2.5. อุปกรณ์อื่น ๆ ที่จำเป็นต่อการทำงานของระบบ

5.3.3. Valve 705-HV-025

5.3.3.1. Push Button switch box (New install)

5.3.3.2. Pressure transmitter for status

5.3.3.3. Solenoid valve

5.3.3.4. อุปกรณ์อื่น ๆ ที่จำเป็นต่อการทำงานของระบบ

6. ผู้รับจ้างจะต้องดำเนินงาน FAT และ SAT อุปกรณ์ก่อนทำการติดตั้งอุปกรณ์
7. การติดตั้งระบบ Grounding ของงานติดตั้ง ให้เป็นไปตามมาตรฐาน ปตท.
8. ผู้รับจ้างจะต้องดำเนินงาน Loop Test หลังดำเนินการติดตั้งแล้วเสร็จ และต้องแจ้งให้ ปตท. เข้าร่วมตรวจสอบ
9. ผู้รับจ้างจะต้องดำเนินงานทดสอบ Control System Function Test รวมถึง Safety Function Test โดยจะต้องแจ้งให้ ปตท. เข้าร่วมตรวจสอบ
10. ผู้รับจ้างจะต้องดำเนินการ Commissioning ระบบ ร่วมกับทางปตท. ว่าระบบสามารถใช้งานได้ตามที่ออกแบบ

Phase 2

11. เปลี่ยน HMI และติดตั้ง PanelView Plus จำนวน 3 ตัว
    - 11.1. CCR ฝั่งหน้า
    - 11.2. Main Sub Station GSP3
    - 11.3. New Sub Station GSP3
12. ดำเนินการ Revamp Push button ของ Deluge valve Tank GSP3 ตามอุปกรณ์ใน Scope of supply ข้อ 6.4
13. ผู้รับจ้างจะต้องดำเนินงาน FAT และ SAT อุปกรณ์ก่อนทำการติดตั้งอุปกรณ์
14. การติดตั้งระบบ Grounding ของงานติดตั้ง ให้เป็นไปตามมาตรฐาน ปตท.
15. ผู้รับจ้างจะต้องดำเนินงาน Loop Test หลังดำเนินการติดตั้งแล้วเสร็จ และต้องแจ้งให้ ปตท. เข้าร่วมตรวจสอบ
16. ผู้รับจ้างจะต้องดำเนินงานทดสอบ Control System Function Test รวมถึง Safety Function Test โดยจะต้องแจ้งให้ ปตท. เข้าร่วมตรวจสอบ
17. ผู้รับจ้างจะต้องดำเนินการ Commissioning ระบบ ร่วมกับทางปตท. ว่าระบบสามารถใช้งานได้ตามที่ออกแบบ

การปฏิบัติงาน

1. ผู้รับจ้างจะต้องทำการเปิด work permit ล่วงหน้าอย่างน้อย 2 วันก่อนเข้าทำงาน ผ่านระบบ work permit online ของทางโรงแยกก๊าซธรรมชาติระยองด้วยตัวเอง โดยทาง ปตท. จะประสานงานในการเพิ่ม username และ password ให้
2. ในระหว่างปฏิบัติในพื้นที่โรงแยกก๊าซ ผู้รับจ้างจะต้องปฏิบัติตามกฎความปลอดภัยของโรงแยกก๊าซธรรมชาติระยองอย่างเคร่งครัดตลอดเวลา ดังนี้
    - 2.1. ผู้รับจ้างจะต้องมีหัวหน้างาน (Supervisor หรือ Foreman) พร้อมสวมใส่ปลอกแขนบ่งชี้ว่าเป็นหัวหน้างานอยู่ที่หน้างานตลอดเวลา ในกรณีที่มีการปฏิบัติงานหลายพื้นที่ จะต้องมีหัวหน้างานอย่างน้อย 1 คนในทุกพื้นที่ปฏิบัติงาน
    - 2.2. ผู้รับจ้างจะต้องมีเจ้าหน้าที่ความปลอดภัย (Safety Officer) พร้อมสวมใส่ปลอกแขนบ่งชี้ว่าเป็นเจ้าหน้าที่ความปลอดภัย อยู่ที่หน้างานตลอดเวลา ในกรณีที่มีการปฏิบัติงานหลายพื้นที่ จะต้องมีเจ้าหน้าที่ความปลอดภัยอย่างน้อย 1 คนในทุกพื้นที่ปฏิบัติงาน
    - 2.3. ผู้รับจ้างจะต้องปฏิบัติงานตาม Scope งานที่อยู่ใน Work permit เท่านั้น หากจะต้องการปฏิบัติงานนอกเหนือ work permit จะต้องทำการแจ้งผู้ควบคุมงาน ปตท. ก่อนเท่านั้น หากไม่แจ้งแล้วดำเนินการโดยพลการ ทางผู้รับจ้างจะต้องเป็นผู้รับผิดชอบความเสียหายทั้งหมดที่เกิดขึ้น และทาง ปตท. จะพิจารณาออกหนังสือเตือนสำหรับการกระทำดังกล่าว

2.4. ผู้รับจ้างจะต้องสวมใส่อุปกรณ์ป้องกันอันตรายส่วนบุคคล ประกอบไปด้วย หมวกนิรภัย, แว่นตานิรภัย, เสื้อแขนยาว, รองเท้า Safety หรือสิ่งอื่นใดตามกฎความปลอดภัยของโรงแยกก๊าซธรรมชาติระยองเป็นอย่างน้อย หากพบเห็นการฝ่าฝืนกฎ ทาง ปตท. จะพิจารณาออกหนังสือเตือนสำหรับการกระทำดังกล่าว

2.5. หากทางผู้ควบคุมงานของ ปตท.พบเห็นผู้รับจ้างไม่ปฏิบัติตาม ข้อ 7.1 ถึง 7.4 หรือพบเห็นการทำงานที่ไม่ปลอดภัย สุ่มเสี่ยงต่อการเกิดอุบัติเหตุหรือเกิดความเสียหายไม่ว่ากับสิ่งใดก็ตาม ทาง ปตท. จะสั่งให้หยุดงานในวันดังกล่าวทันที และสามารถเริ่มงานได้อีกครั้งในวันถัดไป ในกรณีที่เกิดความล่าช้าในการส่งมอบงานให้กับทาง ปตท. แล้วมีค่าปรับ ทาง ปตท. จะไม่มีการยกเว้นค่าปรับดังกล่าวไม่ว่ากรณีใด

3. การตัดสินว่างานเสร็จสิ้นหรือไม่ ให้ทาง ปตท. เป็นผู้ตัดสินแต่เพียงผู้เดียว

4. เนื่องด้วยสภาวะโรคติดต่อ COVID-19 ทางผู้รับจ้างมีหน้าที่ปฏิบัติตามมาตรการของทางโรงแยกก๊าซตาม “เอกสารแนบ_08_มาตรการจัดการโรคติดต่อ COVID-19” หรือตามที่ทาง ปตท. มีการกำหนดในภายหลัง ซึ่งทางผู้รับจ้างจะต้องเสนอราคามาในงานนี้ด้วย ทั้งนี้หากไม่เสนอมา ทาง ปตท. จะไม่ช่วยในเรื่องค่าใช้จ่ายใด ๆ ทั้งสิ้น ทางผู้รับจ้างจะต้องเป็นผู้รับผิดชอบเอง

แบบหรือ Drawing แนบท้าย

1. Plot plan สำหรับอ้างอิง Route สายสัญญาณที่ต้องทำการลากสาย
2. PTT Engineering standard ที่เกี่ยวข้อง
3. Loop Fire & Gas Tank Farm GSP3
4. Cable route plan

สิ่งที่ ปตท. จัดหาให้

1. นั่งร้าน สำหรับงานลากสายโดยทางผู้รับจ้างจะต้องแจ้งล่วงหน้าอย่างน้อย 30 วัน ก่อนเข้าดำเนินการ เพื่อให้ทาง ปตท. สามารถจัดตั้งอุปกรณ์ได้ทันก่อนเริ่มใช้งาน
2. อุปกรณ์ PLC ของ ALLEN-BRADLEY ประกอบไปด้วย Card Controller, Redundant, Communication, Power supply, PanelviewPlus และอุปกรณ์อื่น ๆ ยี่ห้อ Allen-Bradley
3. Barrier ที่ต้องใช้งานในระบบ

PTT PUBLIC COMPANY LIMITED

RAYONG GAS SEPARATION PLANT

APPROVE BRAND LIST

Rev	Date	Description	Made by	Checked (Eng Div)	Checked (Insp Div)	Approved (VP Eng)
11	1 Oct 15	Internal revise	Weradech N.	Suebpong K.	Somros K.	Soranai L.
12	1 Jan 17	Internal revise	Weradech N.	Suebpong K.	Suksan P.	Soranai L.
13	31 Jan 19	Internal Revise	Hirun W.	Sunvaris U.	Suksan P.	Komgrit L.

*= Temporary List (See note 9.)

RAYONG GSP'S BRAND LIST

General Requirement

Contractor shall follow the requirements based on the following understandings.

1. Contractor shall select vendors, for any equipment, who comply with the specifications and other requirements of the Contract form this brand List.
2. This vendors list covers the major equipment and materials supplied by Contractor and include auxiliary equipment and/or materials supplied by the package vendor(s). The package vendors, which are also subject to PTT's approval, shall select brand in accordance with this brand list and considering compliance with the specifications and other requirements of Contract.
3. Revision of brand list when necessary will be possible in the course of job execution but is subject to PTT's approval.
4. For equipment and materials other than categories not listed in the vendor list, Contractor shall select the vendor(s) considering compliance with the specifications and other requirements of the Contract.
5. Goods, equipment and material shall be manufactured / assembled in the country and by the manufacturer specified hereinafter.
6. For all Mechanical, Electrical and Instrument Equipment, PTT shall receive official written confirmation from the Original Vendor for the available of "After Sale Service by Local (Thai) authorized Dealers/Distributors". With such a written confirmation, the Original Vendor certifies that its authorized local dealer/distributor has fully agreed to provide the complete ranges of commissioning and after sale services to PTT and also know well all of information and status relevant to this Project.
7. Contractor shall neglect "Vendors" recommended by Licensor and shall use PTT Vendor List as mandatory.
8. The source of all plate, pipe and fittings used in the fabrication of Pressure Vessels, Heat Exchangers or Pressure Piping Systems shall be subject to PTT approval. Only mills that can demonstrate supply of quality materials shall be used for the project.

*= Temporary List (See note 9.)

9. "Temporary List (*)" is the Equipment which qualified through "document and technical review phase" and must have report from Maintenance or Manufacturing Plant Audit Report to ensure that equipment have qualified with PTT-GSP standard and practices to go through. This report must have within 3 years otherwise this brand will stay in temporary list or remove from list is upon decision of Engineering department manager

*= Temporary List (See note 9.)

TABLE OF CONTENT

*= Temporary List (See note 9.)

*= Temporary List (See note 9.)

*= Temporary List (See note 9.)

*= Temporary List (See note 9.)

*= Temporary List (See note 9.)

1. **<u>Safety and Fire Fighting Equipment</u>**

1.1. Control and Supervisory system

1.1.1. Fire Alarm and Fire Fighting (Building)

- Mirtone	Canada
- Kidde Fenwal	U.S.A

1.1.2. Combustible Gas and Toxic Gas Detection System

- Det-Tronics (SIL 2 Compliance)	U.S.A.
- Allen Bradley (SIL 2 Compliance)	U.S.A.

1.1.3. Fire Fighting Process (Water Deluge System)

- Det-Tronics (SIL 2 Compliance)	U.S.A.
- Allen Bradley (SIL 2 Compliance)	U.S.A.

1.2. Fire Alarm and Fire Fighting equipment

1.2.1. Cylinder, Sensor, Nozzle, Pull Box, Electric Control Head

- Kidde	U.S.A.
- Fike	U.S.A.

1.2.2. Portable Fire extinguisher

- Kidde	U.S.A.
- Ansul	U.S.A.
- Badger	U.S.A.

1.2.3. Wheeled Fire extinguisher

- Kidde	U.S.A.
- Ansul	U.S.A.

1.2.4. Foam equipment

- Angus	U.K.
- Ansul	U.S.A.
- National Foam	U.S.A.

1.2.5. Deluge Valve

- Viking	U.S.A.
- CLA-VAL	U.S.A.

1.2.6. Water power oscillating monitor

- Chemguard	U.S.A.

1.3. Flame Detector

- Det-Tronic	U.S.A.
- General Monitors	U.S.A.

*= Temporary List (See note 9.)

1.4. Gas Detector

- Det-Tronic	U.S.A.
- Dragger	U.S.A.
- General Monitors	U.S.A.

1.5. Safety Shower and Eye Washer

- Nippon Encon Manufacturing	Japan
- Bradley	U.S.A.
- Pratt	U.S.A.

*= Temporary List (See note 9.)

2. Static Equipment

2.1. Column

- By Contractor (See General Requirment)

2.2. Pressure Vessel, Absorbers& Treaters

- By Contractor (See General Requirment)

2.3. Filter ,Separator & Coalescer for Hydrocarbon Service

2.3.1. Hydrocarbon Service

- Pall Corp.	U.S.A.
- Fuji Filter Mfg.	Japan
- PECO	U.S.A.
- Burgess Manning	U.S.A.
- Parker	Japan

2.3.2. Non Hydrocarbon Service

- Pall Corp.	U.S.A.
- Fuji Filter Mfg.	Japan
- PECO	U.S.A.
- Burgess Manning	U.S.A.
- Parker	Japan

2.4. Vessel internal

2.4.1. Column tray/ Distributor/Packing

- Koch Glitsch	U.S.A./Italy
- Sulzer Chemtech	U.S.A.
- GTC Technology	Korea
- Hanbal Masstech	Korea

2.4.2. Demister –wire mesh pad type

- KOCH-OTTO YORK	U.S.A.
- Sulzer Chemtech	U.S.A.

2.5. Spherical Tanks

- By Contractor (See General Requirement)

2.6. Cylindrical Tank

- By Contractor (See General Requirement)

2.7. Tank floating cover

- Vaconodome	Germany
- Motherwell Naylor	U.K.
- Varec	U.S.A.
- CBI	U.S.A.
- Korea Float Co.	Korea

*= Temporary List (See note 9.)

2.8. Shell & Tube Heat Exchanger

- By Contractor (See General Requirement)

2.9. Air Cooled Heat Exchanger

- Hudson	U.S.A.
- Smithco	International
- GEA Reiney	U.S.A.
- S&T Corporation	Korea
- Korean Heat Exchanger	Korea
- Sewon Cellontech	Korea

2.10. Air Cooled Heat Exchanger Fan

- Moore	U.S.A
- Hudson	U.S.A
- Cofimco	International

2.11. Brazed Aluminium Heat Exchanger

- Linde Akiengesellschaft	Germany
- Sumitomo Precision Product. Co., Ltd.	Japan
- Chart Industries	U.S.A.
- Kobelco	Japan

2.12. Plate Heat Exchanger

- Alfa Laval	Sweden

2.13. Accessories

2.13.1. Quick opening closure

- PECO "Safelok"	U.S.A.
- GD engineering "Bandlok"	U.K.

2.13.2. Air Cooler belt drive

- Optibelt	Germany
- Gates	U.S.A.

*= Temporary List (See note 9.)

3. Rotating Equipment

3.1. Gas Turbine

- Siemems (Rolls Royce)	U.K. / U.S.A
- Solar Turbine	U.S.A.
- GE	U.S.A.

3.2. Centrifugal Compressor

- Mann Turbo (Sulzer)	Switzerland
- Ebara Corp.	Japan
- Dresser Rand	U.S.A.
- Cooper	U.S.A.
- Nuovo Pignone	International
- MHI	Japan
- Siemens Compressor	Germany
- Hitachi Compressor	Japan

3.3. Integrally Geared Centrifugal Compressor

- Mann Turbo (Sulzer)	Switzerland
- Kobelco Steel	Japan
- Siemens	Germany

Note

For Sales gas compressor, above vendors are preference. However, contractor may propose alter centrifugal compressor manufacturer for PTT to approval, but the following criteria shall be met as minimum:

1) The manufacturer shall have experienced in package with the proposed Gas turbine model at least 3 jobs, not earlier than year 1996.

2) Operating experience record of the proposed compressor model (same frame size, same arrangement, comparable load), totally 3 units, at least 24,000 operating hours each, shall be submitted by Manufacturer. The record shall describe owner's name, major overhaul / breakdown.

3) The Manufacturer shall have installation record in Thailand at least 3 units.

4) Sales and service office in Thailand shall be presented.

3.4. Turbo Expander

- Atlas Copco (Rotoflow)	U.S.A.
- Mafi-trench	U.S.A.

*= Temporary List (See note 9.)

3.5. Centrifugal Air Compressor & Air dryer package

- Ingersoll Rand	U.S.A.
- Atlas Copco	Belgium
- Kobelco Steel	Japan
- Hitachi Compressor	Japan

3.6. Blower & Fan (exclude fan for A.C.H.E.)

- Chicago Blower	U.S.A.
- Northern Blower	U.S.A.
- Aeromeccanica stranich	U.S.A.
- Boldrocchi	Italy

3.7. Vertical Inline Compressor

- Sundyne/Nikkiso	U.S.A./Japan

3.8. Process Screw Compressor

- Mycom	U.S.A.
- Atlas Copco	U.S.A.
- Kobelco Steel	Japan

3.9. Variable Speed Hydraulic Drive Gear-Torque converter

- Voith	Germany

3.10. Gear box

- Allen	U.K.
- Renk	Germany
- Philadelphia Gear	U.S.A.
- Flender	France

3.11. Diesel engine

- Cummins	U.S.A.
- Detroit Diesel	U.S.A.
- Daihatsu	Japan
- Kubota	Japan

3.12. Centrifugal Pump

3.12.1. Non API Pump

- Ingersoll Dresser Pumps	U.S.A.
- Marushishi	Japan
- Shin Nippon	Japan

*= Temporary List (See note 9.)

- Flowserve	International
- Ebara Corp.	International
- Sulzer	International
- Gould	International
- Groundfoss (Water only)	International
- Durco Pump	International
3.12.2. API Pump	
- Shin Nippon	Japan
- Sulzer	U.S.A./Europe
- Gould	U.S.A./Korea
- Niigata Worthington	U.S.A.
3.12.3. Lean Amine Pump & Turbine	
- Ingersoll Dresser Pumps	Japan
- Sulzer	U.S.A./Germany
- Shin Nippon	Japan
- Niigata Worthington	U.S.A.
3.12.4. Fire pump package	
- Sterling	U.S.A.
- Peerless	U.S.A.
- Fairbanks Nijhuis	U.S.A.
3.13. Vertical Inline Pump	
- Sundyne/Nikkiso	U.S.A./Japan
3.14. Positive Displacement Pump	
- Milton Roy	U.S.A.
- Nikkiso Co.	Japan
- Sakura Seisakusho	Japan
- Marushishi	Japan
3.15. Dry Gas Seal	
- Flowserve	International
- John Crane	International
3.16. Mechanical seal	
- Nippon-Pillar	Japan
- John Crane	International
- Flowserve	International
- Bergman	International

*= Temporary List (See note 9.)

3.17. Rotating Accessories

3.17.1. Rolling element Bearing

- SKF	U.S.A.
- FAG	Germany
- NSK	Japan

3.17.2. Bearing (for Air Cooled Heat Exchanger Fan)

- SKF	U.S.A.
- Dodge	U.S.A.
- FAG	Germany
- NSK	Japan

3.17.3. Tube & Fitting (Mechanical)

- Swagelok	U.S.A.
- Parker	U.S.A.

*= Temporary List (See note 9.)

4. Electrical

4.1. Local Break Switch

- LKE	Netherlands
- Siemens	Germany

4.2. Power Transformer

- Ekarat Engineering	Thailand
- Tira Thai	Thailand
- Toshiba Corp	Japan
- ABB	Thailand

4.3. H.V. Switchgear

4.3.1. 115 kV, 33 kV and 22 kV Switchgear

- Mitsubishi Electric Corp.	Japan
- Toshiba Corp.	Japan
- ABB	Sweden
- Siemens	Germany
- Alstom	France
- AREVA	Germany

4.3.2. 11 kV. And 6.9 kV Switchgear

- Mitsubishi Electric Corp.	Japan
- Toshiba Corp.	Japan
- ABB	Sweden
- Siemens	Germany

4.4. LV. Switchgear, Motor Control Center and LN. Main Distribution Board

- Merlin Gerin	France
- Mitsubishi Electric Corp.	Japan
- Toshiba Corp.	Japan
- Siemens	Germany
- Meidensha Corp.	Japan
- ABB	International

4.5. Bus ducting

4.5.1. Cast Resin type

- Isobusbar (Vilfer Electric)	Spain
- Betobar	Belgium

4.5.2. Sandwich type

- The Furugawa Electric Co.	Japan
- Powerduct	Malaysia

*= Temporary List (See note 9.)

4.6. eactive Power Compensation Capacitor

- Nichicon Capacitor	Japan
- MKS Technology	Germany
- ABB	International
- Merlin Gerlin	France

4.7. Miniature Circuit Breaker

- Mitsubishi	Japan
- ABB	International
- SIEMENS	International

4.8. Wound Rotor Induction Motor

- TMEIC (TOSHIBA / Mitsubishi)	Japan
- Siemens	Germany
- Fuji electric	Japan

4.9. Synchronous Motor

- General Electric (GE)	Canada
- ABB	Switzerland
- Siemens	Germany
- TMIEC (TOSHIBA / Mitsubishi)	Japan

4.10. Electric Induction Motor

- Fuji Electric	Japan
- Mitsubishi Electric Corp.	Japan
- Toshiba Corp.	Japan/Australia
- Siemens	Germany
- ABB	Finland
- WEG	Brazil

4.11. Synchronous Generator

- Siemens	Germany
- ABB	Sweden/ Netherland

4.12. Emergency Generator Unit

- Cummins	U.S.A.
- Detroit Diesel	U.S.A.
- Daihatsu	Japan
- Kubota	Japan
- HIMOINSA	Europe

*= Temporary List (See note 9.)

4.13. Motor Actuator (MOV)

- AUMA	Germany
- Rotork	U.K.
- Bernard*	France

4.14. Electric Heater

- Bartec	Germany
- Elmess-Elektrogeratebau	Germany
- Chromalox	U.S.A./U.K.
- Watlow	U.S.A.

4.15. Soft Starter LV, MV

- Solcon	Israel
- ABB	Switzerland
- Siemens	Germany
- Toshiba / TMIEC	Japan / Australia

4.16. Vary Speed Drive (VSD) for MV. Motor

- ABB	Switzerland
- Siemens	Germany
- Toshiba / TMIEC	Japan / Australia

4.17. Vary Speed Drive(VSD) for LV. Motor

- Siemens	Germany
- Toshiba	Japan
- Schneider	Europe
- Danfoss	Denmark

4.18. UPS and D.C. Charger Unit

- Yuasa Corp.	Japan
- Saft	Germany
- Gutor	Switzerland
- Borri	Italy
- Statron	Switzerland
- AEG	Germany

4.19. Seal Lead Acid Maintenance Free Batteries

- Yuasa	Japan
- GNB	U.S.A.
- Sornenschein	Germany
- Exide	Germany
- Hoppecke	International
- Fiamm	Italy

*= Temporary List (See note 9.)

4.20. Closed Circuit Television (CCTV)

- Pelco	U.S.A.
- Videotech	U.S.A.
- Avigilon	U.S.A.

4.21. Public Address System (PUAS)

- Gai-tronic	U.S.A.
- Comtrol	U.S.A.

4.22. Telephone (Explosion proof)

- Fernsig(Resistel)	Germany
- Gai-tronic	U.S.A.
- Comtrol	U.S.A.

4.23. Local Control Station

- Idec Izumi Corp.	Japan
- Mori Denki Electric	Japan
- Togami Electric	Japan
- O-Z/ GEDNEY	U.S.A.
- Crouse-Hinds	U.S.A.
- Bartec	Germany
- Warom	China

4.24. Explosion proof type Lighting Fixture, Round Box , etc

- Shimada Electric	Japan
- Miyaki Electric	Japan
- Bartec	Germany
- Mori Denki Electric Mfg	Japan
- Killark	Germany
- O-Z / GEDNEY	U.S.A.
- Crouse-Hinds	U.S.A.
- Warom	China
- Alloy	Thailand

4.25. Explosion proof type Junction Box (JB)

- Bartec	Germany
- Stahl	Germany
- Alloy	Thailand
- Warom	China
- Mori denki Electric Mfg.	Japan
- Crouse Hinds	U.S.A.

*= Temporary List (See note 9.)

- CEAG	Germany

4.26. Explosion Proof Plug & Receptacle

- Miyaki Electric	Japan
- Ito Denki	Japan
- Mori Denki	Japan
- Appleton	U.S.A.
- Warom	China

4.27. Indoor Lighting Fixture, Bulb, Switch, etc.

- Philips	Thailand
- Silvania	Thailand
- National/Panasonic	Thailand

4.28. Medium and High Volt Cable (above 1000V)

- Fujikura Electric Co., Ltd.	Japan
- Thai Yazaki Electric Wire Co., Ltd.	Thailand
- Pheldge Dodge	Thailand
- MCI Draka	Israel
- Bangkok Cable	Thailand

4.29. Low Volt Cable

- Fujikura Electric Co., Ltd.	International
- Thai Yazaki Electric Wire Co., Ltd.	Thailand
- Pheldge Dodge	Thailand
- MCI Draka	Thailand
- Bangkok Cable	Thailand
- CTW Charoong Thai Wire & Cable	Thailand

4.30. Split-type air conditioners

- Mitsubishi electric	Japan/Thailand
- Daikin	Japan/Thailand
- Trane	U.S.A./Thailand
- Carrier	U.S.A./Thailand

4.31. Split-type air conditioners (Explosion Proof)

- Warom	China
- MARC	U.S.A.

4.32. Ethernet Switch

- Cisco	International
- Hirschmann	Germany

*= Temporary List (See note 9.)

4.33. Fiber Optic Converter

- Cisco	International
- Hirschmann	Germany

4.34. Protective Relay

- ABB	Germany
- SIEMENS	Germany
- GE	U.S.A./Europe
- Refer to SWGR Vendor (4.3, 4.4)	

4.35. Ring main Unit 22 kV

- ABB	International
- SCHNEIDER	International

*= Temporary List (See note 9.)

5. Control & Instrument

5.1. Distributed Control System (DCS)

- Yokogawa Electric Corp. — Japan/Thailand

5.2. PLC

5.2.1. PLC (Programmable Logic Control) General Application

- Allen Bradley — U.S.A.

5.2.2. PLC (Programmable Logic Control) for Package

- Allen Bradley (SIL2 Compliance) — U.S.A.

5.2.3. PLC (Programmable Logic Control) Shutdown System (Safety PLC)

- Yokogawa (Prosafe RS) — Japan
- Triconex — U.S.A.

5.2.4. PLC (Programmable Logic Control) for Electrical Control & Supervisory, C&S

- Allen Bradley (SIL 2 Compliance) — U.S.A.
- ABB — International

5.2.5. PLC (Anti-Surge Controller)

- CCC — U.S.A.

5.3. Machine Monitoring system

- G.E. Bently Nevada — U.S.A.

5.4. SCADA

- Atos Origin — France

5.5. HIPPS

- Mokveld — Netherland
- Yokogawa — Japan

5.6. Instrument Control Cabinet

- Rittal — International

5.7. IS Barrier

- Peperl + Fuchs — U.S.A.
- MTL — U.S.A.

5.8. Power conditioner, Field Terminal for Foundation Fieldbus

- Peperl + Fuchs — U.S.A.
- MTL — U.S.A.

5.9. Surge Protection

- Emerson — U.S.A.
- Peperl + Fuchs — U.S.A.
- MTL — U.S.A.

*= Temporary List (See note 9.)

- Phoenix Contact — U.S.A./Germany

5.10. Field Instrument

5.10.1. Pressure Transmitter, Diff Pressure Transmitter, Temperature Transmitter

- Rosemount	International
- Yokogawa Electric Corp.	Japan

5.10.2. Turbine Flow Meter & P.D. Meter

- Oval Engineering Co., Ltd.	Japan
- Brooks Instrument Co., Ltd	U.S.A.
- Instromet	Holland
- Daniel	U.S.A.
- Itron	Italy

5.10.3. Variable Area Flow Meter (Rotameter)

- Tokyo Keiso Co., Ltd.	Japan
- Brooks Instrument Co., Ltd.	U.S.A.
- Yokogawa	International

5.10.4. Flow Orifice

- Emerson	U.S.A.
- SAMIL	Korea

5.10.5. Annubar & Pitot Tube

- Rosemount	International

5.10.6. Mass Flow Meter – Coriolis

- Rosemount	International
- Oval	Japan
- Endress+Hauser	Germany
- Yokogawa	Japan

5.10.7. Ultrasonic Flow Meter

- Rosemount	U.S.A.
- Yokogawa Electric Corp.	Japan
- Endress+Hauser	Germany

5.10.8. Magnetic Flow Meter

- Rosemount	U.S.A.
- Yokogawa Electric Corp.	Japan
- Endress+Hauser	Germany

5.10.9. Flare Gas Flow Meter

- GE Panametrics	U.S.A.

*= Temporary List (See note 9.)

5.10.10. Displacement Type Level Instrument

- K-TEK	U.S.A.
- Tokyo Keiso	Japan
- Fisher Control	U.S.A.

5.10.11. Radar Type Level Instrument

- Endress + Hauser	Germany
- Tokyo Keiso	Japan
- Rosemount	International

5.10.12. Differential Pressure Type Level Instrument

- Rosemount	International
- Yokogawa Electric Corp.	Japan/Thailand

5.10.13. Tank Level System

- SAAB	U.K
- Enraf	Netherland

5.10.14. Pressure Switch

- Nagano Keiki Seisakusho Ltd.	Japan
- WIKA	Germany
- SOR	U.S.A.
- Ashcoft	U.S.A.
- Dywer	U.S.A.

5.10.15. Level Switch (Magnetic type)

- Tokyo Keiso Co., Ltd.	Japan
- Magnetrol	U.K./U.S.A.
- SOR	U.S.A.

5.10.16. Pressure Gauge

- Ashcorft	U.S.A.
- WISE	Korea
- WIKA	International
- Nagano Keiki Seisakusho Ltd.	Japan
- Baumer	International

5.10.17. Temperature Gauge

- Nagano Keiki Seisakusho Ltd.	Japan
- Ashcroft	U.S.A.
- Ruger	Switzerland
- WIKA	International

5.10.18. Level Gauge (Transparent type and Reflect type)

- Bunka Boueki	Japan

*= Temporary List (See note 9.)

- Samil	Korea
- Nihon Klingage	Japan

5.10.19. Level Gauge (Magnetic type)

- Bunka Boueki	Japan
- Tokyo Keiso Co., Ltd.	Japan

5.10.20. Thermo-elements Assembly with Thermowell

- Rosemount	International
- Okazaki Mfg. Co., Ltd.	Japan
- Ruger	Switzerland
- Yamari	Japan
- Wika	U.S.A.
- Thermo Electric	Netherlands

5.11. Control Valve

5.11.1. Globe Valve

General Service

- Fisher	U.S.A.
- Masoneilan	U.S.A.
- CCI	International
- Weir	U.K.
- ValTek	U.S.A.
- Samson	Europe

Severe Service / Anti Surge Control Valve

- CCI (Model: Drag)	U.S.A.
- Fisher (Model: Whisper Flo)	U.S.A.
- Masoneilan (Model: V-log)	U.S.A.
- Mokveld (Model: RZD-R)	Netherland
- Samson*	Germany

5.11.2. Butterfly Valve

- Vanessa	Italy
- Tricentric	U.K.
- Tomoe Valve	Japan
- Unicom	Korea
- Fisher	U.S.A.

*= Temporary List (See note 9.)

- Samson	Europe

5.11.3. Diaphragm Valve

- NDV	Japan

5.11.4. Ball Valve

- Becker	U.S.A.
- Metso	Finland

5.11.5. Automation ON-OFF Valve

Ball Valve

- Cooper Cameron	U.S.A.
- KTM	Japan
- Perar	Italy
- Metso	Finland
- Starline*	Italy

Metal Seat Class 6

- Argus	Germany
- Cooper Cameron	U.S.A.

Butterfly Valve

- Vanessa	U.S.A.
- Tricentric	U.K.
- Tomoe Valve	Japan/Korea
- Unicom	Korea

Tank Flush Bottom Valve

- Friatec	Germany

5.11.6. KV valve for Molecular Sieve Application

- Cooper Cameron (ORBIT)	U.S.A.
- Petrovalves	Italy
- Valvtechnologies	U.S.A

5.11.7. Self-Actuating Regulating Valve (Pressure Control Valve)

- Fisher	U.S.A.
- Masoneilan	U.S.A./Japan
- Intromet	Germany

5.11.8. Self-Actuating Regulating Valve (Temperature Control Valve)

- AMOT	U.S.A.

*= Temporary List (See note 9.)

5.12. Solenoid Valve

- ASCO	U.S.A.

5.13. Actuator for Automation ON-OFF Valves

- Bettis	U.S.A.
- Ledeen	Italy
- Rotork	England
- Flowbus	Korea

5.14. Actuator for AOV Valve

- Oval	Korea

5.15. Positioner for Control Valve

- Fisher	U.S.A.
- Masoneilan	U.S.A. / Japan
- Metso	Finland
- Samson*	Germany

5.16. Partial Stroke Device for Automation ON-OFF Valves

- Fisher	U.S.A.
- Masoneilan	U.S.A. / Japan

5.17. Instrument Air Filter Regulator

- SMC	U.S.A.
- Fisher	U.S.A.
- Parker	U.S.A.

5.18. Analyzers

5.18.1. Online Gas Chromatography

- Yokogawa Electric Corp.	Japan
- ABB	U.S.A.
- Daniel	U.S.A.
- Siemens	Germany

5.18.2. Moisture Analyzer

- Panametric	U.S.A.
- AMETEK	U.S.A.
- Michell	U.K.
- Bartec	Germany
- Yokogawa Electric Corp.	Japan

5.18.3. Continuous Emission Monitoring (C.E.M.)

- Siemens	Germany
- Yokogawa Electric corp.	Japan
- ABB	Germany

*= Temporary List (See note 9.)

5.18.4. H2S Analyzer

- C.I. Analitical	
- Yokogawa Electric corp.	Japan
- ABB	Germany

5.18.5. Mercury Analyzer

- NIC Analyzer	Japan
- Mercury Instrument	Germany
- PSA	England

5.18.6. CO2 Analyzer

- Sick maihark	Germany
- Yokogawa Electric corp.	Japan
- ABB	Germany
- Servomax	England

5.18.7. RVP Analyzer

- Grabner	Austria
- ABB	U.S.A.
- ORB	U.S.A.

5.18.8. O2 Analyzer for stack

- Yokogawa	Japan
- Rosemount	International
- ABB	Germany

5.18.9. pH Meter

- Yokogawa Electric Corp.	Japan
- Rosemount	International
- Mettler Toledo	U.S.A.

5.18.10. Conductivity Meter

- Yokogawa Electric Corp.	Japan
- Rosemount	International

5.18.11. Turbidity

- Yokogawa Electric Corp.	Japan
- Rosemount	International
- HF scientific	U.S.A.

5.18.12. Dissolve Oxygen

- ABB	Germany

5.18.13. Calorimeters (Wobbe Index)

- Delta Instrument	U.S.A.

5.19. Analyzer House

- CAE	Singapore

*= Temporary List (See note 9.)

- Yokogawa Electric corp.	Japan
- ABB	Germany

5.20. Flame Scanner

- Honeywell	Japan
- Fire-eye	U.S.A.
- Coen	U.S.A.

5.21. Terminal

- Weidmuller	Germany
- Entrelec	Germany
- Phoenix contact	Germany

5.22. Explosion proof equipment (Junction box, Local control station, etc.)

- Shimada Electric	Japan
- Bartec	Germany
- Stahl	Germany
- Weimuller	Germany
- Rose	Singapore

5.23. Push button, bulb, relay and accessories

- Idec Izumi	Japan
- Omron	Japan
- Telemecanique	France
- ABB	Europe

5.24. Instrument tube, valve, fitting, Sampling equipment and accessories

- Swagelok	U.S.A.

5.25. Manifold Valves

- WHITEY	U.S.A.
- Anderson Greenwood	U.S.A.
- Parker	U.S.A.
- Rosemount	International

5.26. Instrument Cable

- Hitachi Cable	Japan
- Thai Yazaki Electric Wire Co., Ltd.	Thailand
- MCI Draka	Thailand
- Bangkok Cable	Thailand
- Wilson	Thailand
- Phelps Dodge	Thailand
- LAPP Cable*	Italy

*= Temporary List (See note 9.)

5.27. Foundation Fieldbus Cable

- Belden	U.S.A.
- ABB	Germany
- MCI Draka	Thailand

5.28. Fiber Optic Cables and accessories

- Optical Cable Corporation	U.S.A.
- Belden	U.S.A.
- AMP	U.S.A.
- FiberTek	U.S.A.
- Fujikura	Japan/Thailand

5.29. Power Supply Converter

- Phoenix Contact	International
- PULS	Germany
- Weidmuller	Germany

*= Temporary List (See note 9.)

6. Manual Valve

6.1. Carbon steel valve for Hydrocarbon (Gate/Globe/Check)

- Kitz Corporation (Kitazawa Valve)	Japan/China
- POYAM	Spain
- Walworth	Mexico/China(Koflow)
- PK	Korea
- Valvosider*	Italy

6.2. Carbon steel valve for Non-Hydrocarbon

- Kitz Corporation (Kitazawa Valve)	Japan/China
- POYAM	Spain
- Walworth	Mexico/China(Koflow)
- PK	Korea
- Takamisawa (TKM)*	japan
- Valvosider*	Italy

6.3. Stainless steel Valve for Hydrocarbon

- Kitz Corporation (Kitazawa Valve)	Japan/China
- POYAM	Spain
- Walworth	Mexico/China(Koflow)

6.4. Stainless steel Valve for Non-Hydrocarbon

- Kitz Corporation (Kitazawa)	Japan/China
- POYAM	Spain
- Walworth	Mexico/China(Koflow)

6.5. Cryogenic Valve

- Kitz Corporation (Kitazawa Valve)	Japan/China
- POYAM	Spain

6.6. Hot Oil service Valve

6.6.1. Bellow Seal Valve for 12" and below

- SWI	Korea
- PK	Korea
- Lazaro Ituarte	Italy

6.7. Ball Valve

- Grove	U.S.A /Italy
- Cooper Cameron	U.S.A.
- Kitamura Valve Mfg. Co., Ltd.	Japan

*= Temporary List (See note 9.)

-	Perar	Italy
-	Metso	Finland
-	PBV	U.S.A./Czech(MSA)
-	RMA	Germany
-	Bohmer*	Germany
-	Kitz Corporation (Kitazawa)*	Japan
-	LVF*	Italy

6.8. Butterfly Valve

-	Vanessa	U.S.A.
-	Tricentric	U.K.
-	Tomoe Valve	Japan
-	Linde	Germany
-	Unicom	Korea

6.9. Forge Valve

6.9.1 Forged Valve for Hydrocarbon Service

-	Shoritsu Seisakusho Co., Ltd.	Japan
-	Takamisawa (TKM)	japan
-	Henry Vogt Machine CO.	U.S.A.
-	Ilshin	Korea
-	DSI	U.S.A.
-	Bonny forge	Italy
-	OMB	Italy
-	LVF*	Italy

6.9.2 Forged Valve for Amine Service (Full Bore Integral Flange)

-	OMB	Italy
-	Henry Vogt Machine CO.	U.S.A.
-	Ilshin	Korea
-	Bonny forge	Italy

6.10. Safety & Relief Valve

-	Fukui	Japan
-	Crosby / Anderson-Greenwood	U.S.A.
-	Consolidated	U.S.A.
-	Farris	U.S.A.
-	Nakatiki	Japan

*= Temporary List (See note 9.)

6.11. Non Slamming Check Valve

- SPC Process Equipment	U.S.A.
- WEIR	U.K.
- NOREVA	U.K/Germany

6.12. Low Delta P Check Valve

- Goodwin	U.K./Korea
- SPC Process Equipment	U.S.A.
- Weir	U.K.
- Peach	Korea
- Stockham	Australia/U.K.

6.13. Diaphram valve

- NDV	Japan

6.14. Valve interlock ,Lock open, Lock close

- By Contractor (See General Requirement)

*= Temporary List (See note 9.)

7. Piping/Fitting and Piping Miscellaneous

7.1. Carbon Steel Pipe

Original Country

- Japan
- Korea
- West Europe
- North U.S.A.
- South Africa

7.2. Stainless Steel Pipe

Original Country

- Japan
- Korea
- West Europe
- North U.S.A.

7.3. Flange and Fitting

7.3.1. Carbon Steel

Original country

- Japan
- Korea
- West Europe
- North U.S.A.
- South Africa
- Thailand

7.3.2. Stainless Steel

Original country

- Japan
- Korea
- West Europe
- North U.S.A.
- South Africa
- Thailand

7.4. GRP Piping

- Fiberbond	U.S.A.
- Smith Fibercast	U.S.A.
- Ameron	Singapore
- Future Pipe Industries	U.A.E.
- Sarplast	Italy

*= Temporary List (See note 9.)

7.5. Spiral wound & other gasket

- Garlock	U.S.A.
- Klinger	International
- Flexitallic	International
- Valqua	Japan/ Thailand
- Pillar	Japan
- Tombo	International
- Jeil E&S	Korea
- Lamons	International
- Masterpac	Thailand
- Thai Express	Thailand

7.6. Ring joint type Gasket

- Flexitallic	International
- Valqua	Japan/ Thailand
- Jeil E&S	Korea
- Masterpac	Thailand

7.7. Static Mixer

- Sulzer chemtech	U.S.A.
- Hado	Korea
- Lighting	Korea

7.8. Bolts and Nuts

- By Contractor (See General Requirement)

7.9. Spring hanger/Support

- NHK Spring Co., Ltd.	Japan
- Sanwa Tekki Corp.	Japan
- Mitsubishi Steel Mfg. Co., Ltd.	Japan
- Liseg	Germany

7.10. Strainer and 7.11 Sample Color

- By Contractor (See General Requirement)

7.13. Steam trap

- TLV	Japan
- Spirax Sarco	Korea
- Yarway	International
- Armstrong	U.S.A.

7.14. Expansion Joint for Piping

- Senior flexonics

*= Temporary List (See note 9.)

8. Package Equipment

8.1. Elevated Flare package

- John Zink — U.S.A.

8.1.1. Enclosed Ground Flare Package

- John Zink — U.S.A.
- Zeeco — U.S.A.
- Callidus — U.S.A.
- GBA — Italy

8.2. Waste Heat Recovery Unit (Hot Oil)

- Foster Wheeler — U.K.
- John Zink — U.S.A.
- Born — Canada
- Heurtey Petrochem — France

8.2.1. Duct Burner

- John Zink — U.S.A.
- Stork — Netherland
- Five — France
- Dejong — Netherland

8.3. Heat Recovery Steam Generator

- Foster Wheeler — U.K.
- John zink — U.S.A.
- Nippon Furnace Kogyo Kaisha, LTD. — Japan
- MHI — Japan
- Born — Canada
- PCC Sterling Limited — U.K.
- CMI

8.4. Fire Heater

- Born — Canada
- Tulsa Heater — U.S.A.

8.5. Incinerator/Thermal Oxidizer

- Foster Wheeler — U.K.
- John Zink — U.S.A.

8.6. DeNOx System (Selective Catalytic Reduction, SCR)

- Shell — Netherland
- Hitachi Zozen — Japan
- BASF — Germany

*= Temporary List (See note 9.)

8.7. Demin Water System / Sand Filter System

- Organo Corporation	Japan
- Daekum	Korea

8.8. Anti-Foam Doasing System

- FG Zeillig	International
- Hansu	Korea

8.9. Methanol Injection System

- FG Zeillig	International
- Hansu	Korea
- Vikoma	U.K.

8.10. Electric Overhead Traveling Crane/Hoist

- Kone cranes	Finland/France
- Demag / MHE Demag	Germany/Thailand
- Showa Crane	Japan
- Namsung(Crane)/Stall(Hoist)	Korea/Germany

8.11. HVAC system

- Trane	International
- Daikin	International
- Mitsubishi	International
- York	International

8.12. Centralized greasing system

- Lincoln	Germany

8.13. Oil mist lubrication system

- LSC	U.S.A.

8.14. Adsorbent, Molecular Sieve, Consumables

8.14.1. Mercury Adsorbent

- Calgon	U.S.A.
- Procatalyse	France
- Mersorb	U.S.A.
- JMC	U.K.
- UOP	U.S.A.

8.14.2. Molecular Sieves

- Grace	Germany
- Procatalyse	France
- UOP	U.S.A.
- Sud-Chemie	Netherland
- JMC	U.K.

*= Temporary List (See note 9.)

8.14.3. Hot Oil

- PTT — Thailand

8.14.4. Lubricant for Pump

- PTT — Thailand

8.14.5. Chemical treatment for Tempered Cooling Water

- Zitech — International
- Nalco — International

8.14.6. SCR Catalyst

- Cometech — U.S.A./ Germany
- Hitachi Zosen — Japan
- Haldor Topsoe — Denmark/ U.S.A.

9. Miscellaneous

9.1. Plasma/LCD/LED Monitor

- Panasonic	Japan
- Sony	Japan
- Sharp	Japan
- Samsung	Korea/Thailand
- LG	Korea/Thailand
- Dell	International

9.2. Desktop Computer (Server, Workstation)

- Dell	Korea/Thailand
- HP	Korea/Thailand

9.3. Laptop Computer

- Dell	Korea/Thailand
- HP	Korea/Thailand

9.4. Printer

- HP	International
- Canon	International
- Ricoh	International

9.5. Grating

- Webforge (Thailand) Ltd.	Thailand
- Siam Steel Gratings Co.,Ltd.	Thailand

9.6. Hot dip Galvanized Conduit

- Abso	Thailand
- Matsushita	Thailand
- Arrowpipe	Thailand

9.7. Cable Gland

- Hawke	International
- CMP	U.K.
- Peppers	U.K.

9.8. Cable Transit Equipment

- Roxtec	Sweden
- SMC	Thailand
- TIC	Thailand

*= Temporary List (See note 9.)

9.9. Painting for Piping, Structure and building

-	Chukoku	International
-	Jotun	International
-	Dimet	International
-	International	International

*= Temporary List (See note 9.)

REVISION	REV 0	REV 01	REV 02	REV 03	REV 04
DATE	Jan 2005	Mar 2005	Jan 2006	Nov 2019	
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CONTENTS

1.0 SCOPE

1.1 Instrumentation and Control equipment shall be furnished in accordance with this Engineering Standard. Design and Installation of instrumentation shall generally be in accordance with

API RP551 - Process Measurement Instrumentation

1.2 Control philosophy and extent of instrumentation shall be as defined on the Piping & Instrument Diagrams (P&IDs).

1.3 Instrumentation symbols, identification of functions on P&IDs and instrument tag numbering shall be in accordance with the project Equipment Numbering Standard ES-99.01.

1.4 An Instrument List shall be developed by the CONTRACTOR during detail engineering from the Instrument database provided in the FEED package. The Instrument List shall include all tagged instruments, together with relevant data and reference document information.

2.0 GENERAL DESIGN REQUIREMENTS

2.1 Instrumentation and control systems shall be designed to operate within the limits of performance specified and shall be 'fit-for-purpose'. Particular attention shall be given to measurements of streams subject to guarantee values.

2.2 Instrument systems shall be designed to avoid interaction between associated electrical circuits. Spurious signals, which cause interference, shall be suppressed, preferably at source.

2.3 Instrumentation, control system and cabinet shall be designed to protect against the radio interference e.g. walkie takie

2.4 The use of local panels shall be minimised and only used for special package equipment such as compressors or boilers. Field mounted panels shall be suitable for the hazardous area location.

2.5 Signal transmission between field instruments and respective systems E.g. DCS, SIS, etc. The signal transmission type for all field instrumentation shall be:

Signal Type	Signal Level
Analogue (Non-safety system applications, e.g. DCS)	SMART transmitters with 4-20 mA, 24 VDC "HART" protocol / Foundation Fieldbus Protocol (based on control system philosophy
Analogue (Safety system applications, e.g. SIS,)	SMART transmitters with 4-20 mA, 24 VDC "HART" protocol

2.6 All electronic / electrical field mounted instruments shall be protected to IP65 as a minimum, and pneumatic field mounted instruments to IP53. The external finish shall be to manufacturers standard but shall be suitable for the environmental conditions. Particular attention shall be paid to possible effects of corrosion, vibration, humidity, and extremes of temperatures.

2.7 All electronics shall be tropicalized. Vents associated with pneumatic equipment shall be fitted with insect screens.

2.8 Process connections for all instruments shall be ANSI flange connection unless otherwise stated. Pneumatic connections shall be NPTF, normally 1/4" but larger as required, e.g. for high-speed actuators. Electrical entries to instruments shall be ½” NPT.

2.9 Unless otherwise stated, accuracy of instruments shall be:

Local Gauges: $\pm$ 1.0% of full scale
Electronic Transmitters: $\pm$ 0.1% of full scale

2.10 Instruments shall be protected from adverse effects of process fluids (corrosion, condensation, plugging etc) by the use of heat tracing, seal fluids, diaphragm seals, etc as applicable.

2.11 Instruments shall be installed in accordance with the Instrument Installation Standard ES-60.06.

2.12 Instruments shall be positioned to minimise the effects from fire, solar radiation, heat from adjacent equipment, condensation, spillage, rain, wash-water and maintenance activities.

2.13 Field instrumentation shall be located so as to be easily accessible for maintenance either from grade or platform. Adequate space shall be allowed around instruments for maintenance.

2.14 Field instruments shall preferably post-mounted. Posts (or brackets) shall not be attached to removable flooring or handrails, nor shall they be mounted directly on machinery, piping or equipment subject to vibration.

2.15 Local indicators or controls used by the operators shall be located below eye level. Where necessary permanent access platforms shall be provided.

2.16 All field instruments shall be clearly marked with permanently attached stainless steel labels with the following information.

- Tag number
- Manufacturer
- Full model number
- Serial number
- Protection class
- Area classification type (electrical devices only)
- Flange size and rating (flange connected devices only)

2.17 All instrumentation and associated equipment shall be certified as suitable for use in the specified hazardous area.

2.18 All instruments shall be fitted with sunshades to reduce the effects of solar radiation and provide a degree of rain protection.

2.19 Units of measurement:

For a full list of measuring units to be used for this project refer to Appendix A of Basic Engineering Design Data E-99.00.05. Instruments shall read in the following units:

VARIABLE	UNITS	SCALES	CHARTS
Temperature	degree C	Direct reading	0-100 lin
Pressure			
Positive	bar(g), mbar(g)	Direct reading	0-100 lin
Vacuum	bar, mbar	Direct reading	0-100 lin
Absolute	bar(a), mbar(a)	Direct reading	0-100 lin
Differential	bar, mbar	Direct reading	0-100 lin
Level	% of range:	0-100% lin	0-100 lin
	or:		
	mm actual height	Direct reading	

Flow			
Steam	kg/hr	0-10 sq rt (2)	0-10 sq rt (2)
Liquids	m^3/hr	0-10 sq rt (2)	0-10 sq rt (2)
Gas or Vapour	Nm^3/hr	0-10 sq rt (2)	0-10 sq rt (2)
	(at 0 Deg C, 1.013 bara)		
Density	kg/m^3	Direct reading	0-100 lin
Analysers	pH;% O_2,, Mol%, ppm	Direct reading	0-100 lin
Velocity	m/s, km/h	Direct reading	0-100 lin

Notes:

(1) 0°C and 760mm Hg
(2) 0-100 linear if primary element is linear (e.g. vortex).
(3) Direct reading on transmitters.

sq rt Square root
lin Linear

2.20 Packaged Equipment Instrumentation

Instrumentation supplied as part of an equipment package shall meet the requirements of Engineering Standard ES-60.03, such that the manufacturer/ types of instruments supplied are of a common type with the rest of the plant.

Instruments installed on equipment packages shall meet the requirements of the Instrument Installation Standard ES-60.06.

2.21 All instrument equipment shall be design in accordance with hazardous area classification Class I Div II Group C, D as a minimum.

3.0 DESIGN REQUIREMENTS FOR TEMPERATURE INSTRUMENTS

3.1 General

3.1.1 Bi-metallic ‘every-angle’ dial thermometers shall be used for local indication.

3.1.2 Resistance Temperature Detectors (RTD) shall be used for temperature measurement for centralised control and indication, multipoint indication or recording. Thermocouples may be used in selected cases. Refer to 3.1.3. Where used thermocouples shall be ungrounded type.

3.1.3 Thermocouples shall be used only in the following applications: -

a) Where high frequent vibration is present
(e.g. in high velocity steam or gas streams)

b) For measurements above 400°C.

3.1.4 Thermocouples and Resistance Temperature Detector (RTD) assemblies shall be provided with weatherproof (IP65) terminal heads certified for the relevant hazardous area classification. Heads shall be orientated to prevent ingress of water.

3.1.5 In general, all temperature detecting elements shall be installed in thermowells. Exceptions are skin thermocouples on furnaces etc, bearing temperature elements, and motor winding temperature elements.

3.1.6 Where the signal from a temperature-sensing element is used in conjunction with shutdown systems, it shall not be connected to any other device.

3.1.7 All elements shall be duplex type. They shall be separately and permanently identified regarding function e.g. TRC, TI or Spare etc.

3.1.8 Spare elements, which are not used, shall be wired as standby temperature transmitter.

3.2 <u>Thermowells</u>

3.2.1 Thermowells shall be used for thermocouples, resistance elements, bi-metallic thermometers and temperature test points located in lines and in vessels. Exceptions shall only be used for bearing temperature and skin temperature measurements.

3.2.2 Thermowells shall be made of stainless steel, machined from solid barstock. Other alloy material shall be furnished where required by the Piping Material Standard ES-50.02. They shall be tapered and highly polished.

The thermowell material and tag no. shall be clearly stamped on the body (wrench flat) or flange.

3.2.3 Flanged thermowells shall generally be used for all applications, and shall have flanges attached with full penetration welds, Connections to the process and utility pipes shall be as defined in Engineering Standard ES-50.02.

3.2.4 Line mounted thermowells shall have their Wake Frequency checked for acceptability in accordance with ASME /ANSI PTC 19.3.

3.2.5 The installation of a thermowell, shall where possible be in an elbow facing the direction of flow. Where the elbow size is smaller than 3” diameter the elbow shall be increased in size to 3”.

3.2.6 Where a thermowell is to be installed in a straight section of a line whose size is smaller than 4” diameter, the line shall be swaged up to 4” diameter over an 8” length and the thermowell installed in this section

3.2.7 The length of the thermowell shall generally be as per Licensors standard drawing and project specification. Reference may be made to API RP 550-Part1.

3.3 Temperature Gauges and switches

3.3.1 Local temperature gauges shall be dial type with bimetallic elements. They shall be weatherproof heavy-duty type, with 100mm diameter face and adjustable 'every-angle' type head. The arc covered by the scale shall be not less than 270 degrees.

3.3.2 Temperature gauges shall be accurate within ± 1%

3.3.3 Over range protection shall be provided as follows

≤ 150 °C	+20%
> 150°C	+10%

3.3.4 Capillary type thermometers shall not be used, except in certain cases for machinery and package equipment. Where used, capillary tubing shall be corrosion resistant, sheathed and stainless steel armoured. Capillary tubing shall be supported throughout its length.

3.3.5 Gauges shall be constructed of stainless steel or other corrosion resistant material.

3.3.6 Stem diameter and immersion length of temperature gauges shall be the same as for equivalent RTD's and thermocouples (8mm diameter preferred). Temperature gauges shall be fitted in thermowells using ½" NPT connection. Thermowells shall be as specified in section 3.2.

3.3.7 Temperature switches in the field shall not be used.

3.3.8 Temperature switching required for alarm, shutdown, interlock and control shall be achieved by using a transmitter in the field sending a signal to the rack room. Switching shall be performed in the related control or safety system, or by a separate trip amplifier, as applicable.

3.4 RTD's and Thermocouples

3.4.1 Resistance elements shall comply with IEC 60751 and have a resistance of 100 ohms at 0º C. They shall be class A grade accuracy, mineral insulated and stainless steel sheathed to 8mm dia. All RTD assemblies shall use a three-wire system.

3.4.2 RTD's shall be fitted in thermowells using ½" NPT connection. Thermowells shall be as specified in section 3.2

3.4.3 For temperatures up to 1100° C, thermocouples shall be manufactured from nickel/chromium - nickel aluminium (Type K) in accordance with IEC 60584-1.

3.4.4 For temperatures above 1100º C, noble metal thermocouples shall be used.

3.4.5 Thermocouples shall be mineral insulated. The sheath material shall generally be 321 series stainless steel up to 850ºC, 310 series stainless steel up to 1100ºC and ceramic sheathed above 1100º C. The sheath shall have an 8mm diameter in accordance with IEC 60584-1. The hot junction shall be insulated from the sheath.

3.4.6 Thermocouple head terminals shall be marked with positive and negative symbols.

3.4.7 All elements shall be duplex type. They shall be separately and permanently identified regarding function e.g. TRC, TI or Spare etc.

3.4.8 Signals from RTD's and Thermocouples used in conjunction with a shutdown system shall not be connected to any other device.

3.5 Temperature Transmitters

3.5.1 Temperature transmission shall be by head-mounted transmitters, except where this is not practical due to accessibility or ambient conditions, for high temperature applications where consideration shall be given to remote mounting to avoid exceeding the maximum temperature rating of transmitter electronics.

3.5.2 The transmitter range shall have the normal temperature in the middle third of the range with the manufacturer's narrowest standard span appropriate to the application

3.5.3 Transmitters shall include 'burn-out' protection. The design shall enable this feature to be switched in or out. Elements operating high temperature alarms or shutdowns shall have upscale burnout protection. Those operating low temperature alarms or shutdowns shall have downscale burnout protection.

4.0 DESIGN REQUIREMENTS FOR FLOW INSTRUMENTS

4.1 General

4.1.1 Differential type orifice meters shall be used for flow measurement in accordance with AGA Report 3.

4.1.2 For certain applications, magnetic, variable area or vortex flowmeters shall be used subject to approval by PTT/CONSULTANT.

4.1.3 Rates of flow shall normally be measures by square edged concentric orifice plates.

4.2 Orifice Plates & Venturi's

4.2.1 For pipe sizes 2" and larger, square edged orifice plates are preferred. Orifice plates shall be calculated, manufactured and installed in accordance with AGA Report 3.

4.2.2 For pipe sizes ≥ 2" and < 24", orifice plates shall be installed between orifice flanges with flange taps, manufactured in accordance with ANSI/ASME B16.36

4.2.3 For pipe sizes >1" and <2" an integral orifice meter shall be used.

4.2.4 For pipe sizes ≥ 24", a differential pressure measurement device shall be installed between conventional flanges with pressure tappings at D and D/2.

4.2.5 The material for orifice plates shall be compatible with the fluid handled. As a minimum, they shall be austenitic stainless steel. Each orifice plate shall be stamped with the following as a minimum

- The word UPSTEAM
- The tag no (in one line)
- The orifice bore diameter (d in mm)
- Piping Diameter (D in mm)
- The material of orifice plate

Letter high shall be approximately 4 mm.

4.2.6 Horizontal metering runs shall be used wherever possible for liquid flow measurement. Vertical runs with downward flow shall only be used for steam and other condensible fluids, and upward flow for liquids near their boiling point. In horizontal lines the tappings shall be located in the upper quadrants for gases/vapours and in the lower quadrants for liquids.

4.2.7 Venturi nozzles shall be used where a low pressure-drop is required, or for high-pressure steam.

4.2.8 Primary elements shall be calculated. The value of diameter ratio (d/D) shall be in the range 0.3 to 0.7

4.2.9 Vent holes shall be provided for liquid flows. Drain holes shall be provided for gas, steam and vapor flow. The size of the vent and drain hole shall be in accordance with ISO 5167 Part 2.

4.2.10 Orifice flanges shall be we welding neck type and be in accordance with ASME B16.36 Pressure rating shall be class 300 as a minimum. Flange facing shall be raised face unless otherwise specified. Pressure tap holes shall be 1/2 inch NPTF

4.3 Differential Pressure Instruments

4.3.1 The full scale range of a differential pressure flow meter shall be chosen from the following:

0-50 mbar, 0-100 mbar, 0-250 mbar (preferred), 0-500 mbar

4.3.2 As a minimum, a five-way valve manifold shall be provided at the differential pressure instrument.

4.3.2 The use of liquid seals is not recommended where it is necessary to protect the instrument from the process fluid or from viscous liquids. In such cases, seal damper shall be used. Diaphragm seals are preferred for this application

4.4 Variable Area Flowmeters

4.4.1 Variable Area meters (rotameters) shall be used where shown on P&IDs. They may be considered for the following applications

Varying viscosity
Line size ≤ 2”
Local indication

4.4.2 Glass tube meters shall be used **only** in non-hazardous service and for temperatures up to 130 degrees C. Unprotected glass tube meters shall not be used in any other applications, metal tube meters shall be used.

4.4.3 Meters shall be sized such that normal flow rate is between 50% and 75% of full scale, and minimum and maximum flow rate is between 10% and 90%.

4.4.4 Variable area meters shall be located with sufficient clearance to permit tube and float removal without removing the meter body.

4.4.5 If the flow cannot be interrupted during plant operation, line size block and bypass valves shall be provided.

4.5 Coriolis Meters

4.5.1 Coriolis meters shall be used for flow measurement in accordance with API MPMS Chapter 5 Section 6 and AGA Report No.11

4.5.2 Meters installed in horizontal lines are preferred. Installation in vertical lines, with flow upward, is permitted only where it is not possible to comply with the preferred arrangement. Horizontal lines shall be pocketed to ensure meters run full at all times.

4.5.3 Meters shall be installed between flanges with pipe supports as necessary in accordance with the meter manufacturer recommendations.

4.5.4 Meters in liquid measurement service shall be installed such that the vibrating tubes instrument casings project below the process line. In gas measurement service they shall project above the process line.

4.5.5 Coriolis Meters shall be accurate within ± 0.10% of Reading ±zero stability error and flow rate repeatability within 0.05% of Reading ±zero stability error

4.5.6 Coriolis meters shall be applied for both liquid and gas, but not applicable for two phase flow or steam service where accumulation of internal deposits may be of concern. Coriolis flow meters are capable of measuring both uni-bidirectional and bi-directional mass flow and are able to be used in high viscosity and / or density variations services.

4.5.7 Coriolis meters shall not be used in oscillating flows, in vibrating pipe installations, or steam service.

4.5.8 Body and tube materials shall be stainless steel. Vendor shall advise if stainless steel shall not be suitable with process fluid. The use of other materials requires PTT's approval.

4.5.9 Coriolis sensor shall be hermitically sealed to avoid corrosion.

4.6 <u>Fiscal Metering Stations</u>

4.6.1 A gas flow metering system shall be provided for external import/export metering of product streams. The system and associated instrumentation shall be as specified in the Gas Flow Metering System Functional Design Engineering Standard ES-60.09.

4.6.2 A dedicated flow computer with necessary transmitters shall be provided to compensate for pressure, temperature and density variations.

4.6.3 Import/export metering accuracy shall be at least 0.15% of full scale

5.0 DESIGN REQUIREMENTS FOR LIQUID LEVEL INSTRUMENTS

For the general requirement of level instrument, nozzles to be install level instruments shall separate for each one. Stand pipe shall not be used except subject to approval by PTT/CONSULTANT

5.1 <u>Differential Pressure Level Transmitters</u>

5.1.1 This is the preferred type of instrument for liquid level measurement.

5.1.2 Standpipes on vessels shall not be used.

5.1.3 Zero elevation or suppression, where required, shall be calculated in the DCS, not the transmitter. Transmitters shall be fitted with a 5-valve manifold.

5.1.4 For viscous or corrosive fluids, diaphragm flange-mounted transmitters shall be considered.

5.1.5 For large level ranges, remote diaphragm seals with capillaries shall be considered.

5.1.6 For large specific gravity variation - more than 0.075, ultrasonic type shall be considered.

5.1.7. Differential pressure level measurements shall be applied for liquid services with constant Specific Gravity (SG.) only.

5.1.8 All wetted parts, including diaphragm seals, shall be made from 316 SST as a minimum. Vendor shall advise if 316 SST shall not be suitable with process fluid. The use of other materials requires PTT's approval.

5.1.9. Diaphragm seal shall be applied for high viscosity, aggressive, slimy or suspended solids liquid services.

5.1.10 Diaphragm seal, if use, shall be suitable for use with the applicable temperature and pressure rating.

5.1.11 Capillary tube for remote diaphragm seal shall be 316 stainless steel armoured type with PVC coating to avoid the ambient effects of daytime temperature.

5.1.12 Silicone fill fluids are generally selected. However, the rated service temperature for is not suitable for high temperature service. Seal fluids selection for high temperature services shall be performed in consultation with the VENDOR, to ensure the appropriate seal fluid is selected.

5.1.13 Where diaphragm seals are applied, flushing rings with vent and drain valves shall be provided. The isolation valve required for removal the diaphragms shall be provided.

5.2 Displacer Level Transmitters

5.2.1 Displacer level transmitters shall be used for measuring ranges up to 800mm.

5.2.2 Displacer level transmitters shall be installed in external cages supplied by the manufacturer of the instrument. The displacer cage shall be installed with vent and drain valves.

5.2.3 The cage shall be connected to the vessel / tank via piping class primary isolation valves. The preferred connection style is side / side arrangement.

5.2.4 The torque tube shall be made of Inconel. The transmitter head shall be rotatable for accessibility.

5.2.5 In the case of operating temperatures greater than 200 degrees C, external cooling fins shall be fitted.

5.2.6 Displacer and float material shall be 316 stainless steel, equivalent or higher specification than the vessel material.

5.2.7 Spring material shall be the same as displacer material for electric material measurement.

5.2.8 Cage material shall be 316 stainless steel or higher specification than the vessel material

5.3 Gauge Glasses

5.3.1. Magnetic type may be used corrosive and toxic liquid services.
Tube shall be >=1" diameter with 316 SS (or better) magnetic float. The floats shall be magnetic around their full circumference.

5.3.2. For acid, Hydrocarbon, caustic, dark media, oil and steam condensate, transparent reflex type shall be used. For glass-corrosive duty (e.g. acid caustic, high-pressure steam or condensate), the glass shall be protected with a mica sheet between glass and gasket.

5.3.3 For interface measurement where ρ <= 500 kg/m3 a transparent glass tube type shall be used together with an illuminator, which shall be certified for the hazardous area.

5.3.4 Vessel connections shall be side-side. All gauges shall be supplied with a shut-off valve on the top and bottom mountings and a full bore drain valve. Shut-off valves shall be of a quick acting, offset type and shall have bolted bonnets.

5.3.5. A vent valve shall be provided on toxic services or on corrosive liquid and liquid interface duties to allow for piping for safe fluid disposal. A vent plug shall be provided where a vent valve is not fitted.

5.3.6 Through vision and reflex gauges shall be fitted with toughened glass.

5.3.7 All gauges shall be fitted with ball check valves.

5.3.8 When two or more gauge glasses are required to cover a monitoring range. the visible portions shall overlap by at least 25 mm (1 inch).

5.4 Level Switches

5.4.1 Level switches shall be float type. The float shall be 316 SS.

5.4.2 Switch contact shall be SPDT rated 5A 220v 50Hz and 1A 24v DC.

5.5 Tank Gauging

5.5.1 Product tank gauging shall be to fiscal accuracy as it may be used for import/export product measurement. Approval of local Thai authorities (Customs & Excise etc) is required.

5.5.2 Radar gauges shall be installed on stilling wells in the new product spheres, and connected to the tank gauging system.

5.5.3 The level data from the tank gauging system shall be transmitted to the DCS by serial link for level indication. In addition, tank tables shall be input to DCS to enable tank volume calculations to be performed.

5.5.4 The same type of measurement, but independent units shall be used for control and safeguarding functions.

6.0 DESIGN REQUIREMENTS FOR PRESSURE INSTRUMENTS

6.1 Range Selection

6.1.1 Pressure ranges shall normally be selected in accordance with ANSI/ASME B40.1. For greater discrimination, narrow span transmitters with elevated zero may be used.

6.1.2 Pressure elements measuring a steady normal operating pressure shall not exceed 75% of their maximum range. Pressure elements measuring a fluctuating pressure shall not normally be operated beyond 60% of their maximum range.

6.1.3. For the measurement of slurries, viscous or highly corrosive fluids for which a Bourdon tube or a bellows element is unsuitable, a liquid filled diaphragm sealed element shall be used. Material shall be 316 SS minimum.

6.1.4 For the measurement of steam or hot vapour, siphons (pigtails) shall be installed.

6.1.5 Gauge pressure indicators and transmitters shall be provided with 2-valve manifolds. Differential pressure instruments shall be provided with 5-valve manifolds.

6.2 Pressure Gauges

6.2.1 Pressure gauges shall generally be bourdon-tube type, with 316 SS bourdon element and stainless steel movement. Process connection shall be ½” NPTM (¼” NPTM for pneumatic receiver gauges).

6.2.2 Pressure gauges shall be 150mm diameter, manufactured from SS or other non-corrosive material. They shall be weatherproof with shatterproof safety glass fronts.

6.2.3 All process pressure gauges shall be supplied with a safety blow-out disc.

6.2.4 Gauges measuring pulsating pressures shall be fitted with externally adjustable pulsation dampers. The use of partially closed isolation valves is not permitted.

6.2.5 Over range protection up to 130% of full scale shall be provided by design or by the use of a separate over-range protector.

6.2.6 Gauges for the measurement of differential pressure shall be of the bellows or diaphragm type.

6.3 Pressure Transmitters

6.3.1 All transmitters shall be certified intrinsically safe, suitable for the worst-case site area classification, whether or not they are installed in a hazardous area. This is to avoid accidental installation of an inadequately certified instrument in a hazardous area.

6.3.2 Transmitters shall have local indication.

6.4 Installation

6.4.1 Gauges and indicators shall be positioned for easy reading.

6.4.2 Pulsation dampers and over-pressure protectors shall be fitted close to the pressure measuring element on the rear side.

6.4.3 Piping connections for pressure instruments with or without diaphragm seals shall be flanged 1" to ANSI B16.5, rated as required by the related Piping Class. Vessel connections for pressure instruments shall be flanged 2" to ANSI B16.5, as a minimum and rated as required by the Vessel Trim Code.

6.4.4 The orientation and location of pressure tappings shall ensure:
- i) Ease of access for maintenance
- ii) Freedom from blockage and self-draining or venting properties.
- iii) Avoidance of vibration
- iv) Avoidance of internal fitments such as demister pads, stirrers and nozzle locations that will affect quality of measurement.
- v) Avoidance of long impulse lines.

6.5 Pressure Switches

6.5.1 The use of pressure switches is not permitted.

7.0 CONTROL AND MONITORING SYSTEMS

7.1 The control and monitoring of the process shall be performed by a Distributed Control System (DCS) operated from the Control Room located in control building.

7.2 System cabinets and marshalling cabinets shall be located in the Instrument Rack Room.

7.3 The DCS shall be designed in accordance with Engineering Standard ES-60.05.

8.0 DESIGN REQUIREMENTS FOR CABINET

The VENDOR’s standard system cabinets shall normally be used provided the following minimum requirements are adhered to:

- Cabinets to be free standing and constructed taking into account delivery and installation requirements (multi-pin plug and sockets shall be used between shipping breaks e.g. Elco plugs)
- Cabinets to be mounted on sub-floor mountings suitably designed to withstand normal plant vibrations
- Overall cabinet dimensions to be 2100mm high x 800mm wide and 800mm deep with double front and rear removable and lockable hinged doors
- Cabinet protection class IP 30 minimum
- Cabinet finish to be smooth and follow the colour table below;

Description		Muncell code	RAL colour	Finish
	Exterior	7.5GY 7/2	7032	Semi gloss
Panel	Interior	7.5GY 7/2	7032	Semi gloss
	Channel base	7.5GY 7/2	7032	Semi gloss

- Separate and isolated cabinets earthing connections shall be provided as follows:

– Safety earth (cabinets and steelwork)
– Signal earth (cable screens and signal common)

- The cabinet layouts are to allow full and easy access for installation and maintenance requirements
- Cable access shall be bottom entry via suitable cable clamping mechanisms
- Utility power supplies shall be provided separated from UPS such as conventional type receptacles, fluorescent Lighting.

9.0 INSTRUMENT INSTALLATION

9.1 General

Instruments shall be installed in accordance with API RP551. Specific requirements for instrument installation are given in Engineering Standard ES-60.06.

9.2 Instrument cabling

9.2.1 All multicore cables between field junction boxes and the Rack Room shall be steel wire armoured type.

9.2.2 Cables will have PVC fire self-extinguishing external sheath, black colour for normal loops and blue colour sheath for “intrinsically safe” circuits.

9.2.3 Conductors shall be sized as follows:

- Power supply (24v DC, 220v 50Hz)
  Minimum 1.5mm^2 2 core

- Alarm and status signals ≈ 24v DC
  1.25mm2 twisted pair with overall shield

- Analogue signals (4-20mA)
  1.25mm2 twisted pair with overall shield

- RTD temperature elements
  ≥ 1.25mm2 twisted triad with overall shield.

- Thermocouple cables
  ≥ 1.5mm2 twisted pair extension wire with overall shield

- Solenoid valves
  1.5 – 2.5mm2 for EEx(d)
  1.5mm2 for EEx(i)

For distances greater than 100m, volt-drop calculations shall be carried out to verify the conductor size required.

9.2.4 All signal wires (< 65volt) shall be twisted pairs with individual and overall shields. Signal wiring shall be routed to avoid radio frequency interference (RFI) and electromagnetic interference (EMI) as far as possible.

9.3 Junction Boxes

9.3.1 Junction boxes shall be of stainless steel design. Separate junction boxes, with associated separate multicore cables, shall be used for different signal categories as follows.

- 24v DC solenoid valves (non-i.s.)
- 24v DC alarm and trip signals (i.s.)
- 24v DC alarm and trip signals (non-i.s.)
- 4-20mA signals (i.s.)
- 4-20mA signals (non-i.s.)
- RTD signals (i.s.)
- Thermocouple signals (i.s.)

9.3.2 Cables and JB's for "intrinsically safe" loops shall be separate from cables and JB's for non-i.s. loops. For intrinsically safe circuits, the JB shall have blue coloured lables and the JB terminals shall also be identified by blue colour.

9.3.3 All cable entries into junction boxes shall be from below or from the side. Top entry is not permitted. Correctly certified cable glands for armoured cables shall be used

9.4 Cable Installation

9.4.1 Cables shall be supported on overhead cable trays. (No underground cables). Cable tray shall be hot-dipped galvanised steel.

9.4.2 Protective metallic covers shall be provided on all main cable tray, and also on branch cable trays where they are exposed to accidental damage or spillage of harmful liquid. Main cable trays shall be routed on the top layer of the pipe rack.

9.4.3 All cables from individual field instruments shall be protected by a rigid galvanised steel open conduit system. Closed conduit is not permitted.

10.0 ELECTRICAL POWER SUPPLIES AND GROUNDING SYSTEMS

10.1 Power Supplies

10.1.1 Power supplies to instrumentation and control systems shall be designed to avoid plant upset or shutdown due to voltage dips, surges or power failure.

10.1.2 The following electrical power supplies shall be used:

220V ± 10% 50Hz 1 phase UPS with isolated neutral, from inverter with battery backup, for DCS, ESD, PLC, package instrumentation, analysers, tank gauging, metering, heat tracing etc.

24Vdc ± 10% UPS, for solenoid valves, relays etc. This voltage will be transformed from the 220V UPS supply.

220V ± 10% 50Hz 1 phase with isolated neutral from electrical network, for non-critical users not concerned with plant operation
(e.g. illuminators for level gauges, lighting in cabinets and panels)

10.1.3 Where 24V dc is used over long distances, the voltage drop in field cables shall be carefully calculated to ensure adequate voltage is available at the field device for reliable operation.

10.2 Instrument Grounding

10.2.1 The grounding of measurement, control and computer systems shall be arranged to prevent electrical interference.

10.2.2 Particular attention shall be given to the arrangement of earthing circuits to prevent unwanted circulating currents in earthing, signal and measurement conductors and screens.

10.2.3 The grounding system for plant instrumentation consists of three different and independent grounding rod systems, as follows.

Protection Ground, shall be connected to the Electrical common ground system. This is used for personal safety, for cabinets, instrument racks, support steelwork etc. Resistance to ground shall be ≤ 5 Ω. Green-yellow colour outer sheath shall be used for this type of cable.

DCS Ground, which shall be designed and executed in accordance with the DCS Supplier's recommendations. (Separate rod system for DCS only). Resistance to ground shall be ≤ 1 Ω. Dark blue colour outer sheath shall be used for this type of cable.

Shield Ground, which is available for all instrument grounding requirements (shielding, other microprocessors etc). Cable shields shall be connected at the first incoming cabinet in the rack room. At all other points, shields shall be isolated. Resistance to ground shall be ≤ 1 Ω. Solid green colour outer sheath shall be used for this type of cable.

IS Ground, which shall be designed and executed in accordance with the IS instrument equipment. Resistance to ground shall be ≤ 1 Ω. Blue-yellow colour outer sheath shall be used for this type of cable.

11.0 INSTRUMENT AIR SYSTEMS

11.1 Dried, filtered, oil-free compressed air shall normally be made available at plot limits at a pressure of not less than 7 barg when under rated load.

11.2 Instrument Air shall be distributed within the plot area by a ring main system. The system shall be designed to permit effective drainage.

11.3 Individual filter-regulators equipped with pressure gauges shall enable the supply to each pneumatic instrument to be regulated individually.

11.4 Refer to Basic Engineering Design Data ES-99.00 for details of the available instrument air supply.

11.5 Valve actuators shall be sized to operate down to 5.0 bar (a) minimum.

11.6 The instrument air system shall be designed on the following basis:

Air Header (piping)	-	galvanised steel or equal
Instrument tubing	-	¼" or ½" od 316SS minimum (not copper)
Instrument fittings	-	316 SS, Swagelock compression type, NPT

11.7 All data and alarm from Instrument air package shall be transferred DCS to allow the operator to monitor and control the system.

12.0 INSTRUMENTS IN HAZARDOUS AREAS

12.1 Instrumentation shall be certified as suitable for use in the specified hazardous area. Field instruments shall be certified even if they are installed in a ‘safe’ area of the plant. This is to avoid uncertified field devices being accidentally installed in a hazardous area. The following certifying bodies are approved:

CENELEC/BASEEFA
JIS
NEC

12.2 As far as possible, intrinsically safe equipment shall be used. If EEx (i) instrumentation is not suitable or available, EEx (d) or EEx (e) equipment shall only be used subject to approval of PTT/CONSULTANT.

12.3 In special cases it may be only be possible to use air-purged devices EEx (p). This shall require specific approval of PTT/CONSULTANT.

12.4 Ex certificates shall be provided for all hazardous area instruments and devices.

12.5 Intrinsically safe loop calculation sheets shall be provided covering all i.s. instruments.

12.6 All intrinsically safe instrument circuits shall be identified by blue marking (cable sheath, terminals, junction boxes etc).

13.0 DESIGN REQUIREMENTS FOR CONTROL VALVES

13.1 Valve Selection

13.1.1 Control valves for process liquids, and high-pressure steam and gases shall in general have globe bodies. They shall be fitted with single-seated trim with plug or stem guiding, double-seated trim which shall be top and bottom guided, or cage trim.

13.1.2 Large volume flows and high shut-off differential pressures may be controlled by full bore ball valves or characterised ball valves. Large volume flows are defined as those resulting in globe valve body sizes of DN150 (6") and above. High shut-off differential pressures are those requiring greater force than can be obtained from diaphragm actuators on normal signal pressure.

13.1.3 All control valves require noise (sound pressure) level calculations. Predicted noise level at 1m downstream shall not be greater than 82dBA. Control valves requiring special trim for noise reduction shall have globe bodies with cage trims.

13.1.4 All valves shall be supplied with stem position or rotation indicators.

13.1.5 Self-acting valves shall be used for local, fixed gain control of utilities, such as fuel systems, and where failure action and lower precision of such devices is acceptable.

13.1.6 When 50% or more of the dynamic pressure drop is to be sustained by the control valve at normal flow conditions, the valve shall have a linear characteristic; otherwise it shall have equal percentage trim.

13.2 Valve Sizing

13.2.1 The size of control valves shall be calculated using the formulae from ISA 75.01 or Manufacturer's recommendations. Valve sizing shall be based on 1.1 times maximum flow at the given pressure drop.

13.2.2 In general, control valves shall be sized to pass at least anticipated maximum flow rate at the permissible pressure drop for the flow rate. Range ability shall be checked for the anticipated minimum flow rate. Inner valve shall provide the specified design flow coefficient CV in the following operating range unless otherwise noted.

Equal percent plug	:	60 to 85% of full stroke
Linear plug	:	50 to 80% of full stroke

For control in a pumped circuit the pressure drop allocated to the control valve shall be not less than 20% of the total friction losses in the system.

13.3 Valve Construction

13.3.1 Control valves shall be flanged to ANSI B16.5.

13.3.2 The minimum nominal size of globe and ball valve bodies shall be DN25 (1"). The minimum nominal sizes of butterfly valves shall be DN100 (4").

'Non-standard' body sizes (e.g. 1¼", 2½", 5") shall not be used.

13.3.3 On-off valves operated by the ESD or safety interlock systems shall be full-bore type. On-off valves in the gas treating system shall be rising stem ball valves. All on-off valves shall have flanged end connections.

13.3.4 Emergency shutdown and blowdown valves shall be of fire-safe design according to API6F.

13.3.5 Body/trim materials and pressure rating of control valves and on/off valves shall be in accordance with Piping Material Standard ES-50.02.

13.3.6 Standard packing shall be PTFE V-ring up to 200°C. For operation above 200°C, high-temperature packing or lubricators with isolating valve and finned bonnet shall be used.

Prohibition - The use of asbestos in any form is strictly prohibited in any valve packing or jointing material. Industry best alternatives shall be used.

13.3.7 Soft seating materials shall be used only where tight shut off cannot be achieved with hard-seated or metal-seated valves. They shall not be used where the process medium contains aromatic gases.

13.3.8 Materials for sour service shall conform to the requirements of NACE Standard MR-01-75.

13.3.9 The shaft on a butterfly valve shall be continuous, through the vane, which shall be rigidly locked to the shaft.

13.3.10 The direction of flow through a valve shall be permanently marked on the body or flanges.

13.3.11 The acceptable degree of seat leakage shall be in accordance with process requirements, based on ANSI / FCI 70-2. Leakage class shall be shown on the process data sheets.

13.3.12 Special bonnets shall be specified in following circumstances: -

a) Extension bonnet - for fluid temperatures from 0 to minus 100°C or above +230°C.

b) Bellows seal bonnet - shall be used only when stem leakage can not be tolerated. It shall be fitted with a monitor for bellows leakage, e.g. small pressure gauge and excess flow valve.

13.4 End Connections

13.4.1 The face to face dimensions shall comply with ANSI BS16.10 for all designs of valves with the exception of wafer type, between flange valves, e.g. butterfly valves.

13.4.2 The body end flanges of all flanged valves shall be drilled for through bolting. Flanges that are drilled and tapped for studs are not acceptable.

13.4.3 Gasket surface finish for raised face flanges shall be in accordance with ANSI B16.5 para 6.4.4.

13.5 Actuators

13.5.1 Valves shall be normally operated by spring return diaphragm actuators.

13.5.2 The normal operating range shall be 0.2 to 1.0 barg and shall not exceed 4.0 barg.

13.5.3 Piston actuators shall be used to provide longer strokes or greater thrust than is available from spring diaphragm units. They shall be sized to operate at a minimum air supply of 4 barg.

13.5.4 Double-acting piston actuators, which do not automatically fail to safe position in the event of air failure, shall be avoided. A local air receiver, with sufficient capacity for at least two operations over the full travel of the valve shall be supplied with these actuators. Air receivers shall be supplied with full pressure vessel certification.

13.5.5 Motor operated actuators shall be used for remote operated gate valves (jetty and tankage), and valves larger than 12" body.

13.5.6. Valve actuators shall be sized for the maximum upstream pressure with the downstream pressure taken as zero.

13.6 Accessories

13.6.1 Control valves shall normally be provided with electro-pneumatic positioners, which shall be Foundation Fieldbus type accepting a 4-20mA signal and providing diagnostic data to the DCS. Positioners shall be fitted with gauges.

13.6.2 Solenoid valves for shutdown valves shall be 24v dc EEx (d) with local manual reset. Where specified on the P&ID, for high reliability, two solenoid valves in series shall be used. Solenoid valves installed on sequence valves shall have a facility for local manual actuation.

13.6.3 Double block and bleed valves, or similar valve combinations shall have a separate solenoid valve for each single block. One combination solenoid valve is not allowed.

13.6.4 Trip solenoid valves initiated by a shutdown system to override modulating valves shall be fitted directly into the actuator supply line, not the signal line.

13.6.5 On-off valves shall be fitted with inductive type EEx (i) limit switches.

13.6.6 A side-mounted handwheel shall be fitted to control valves where alternative by-pass arrangements are not provided by: -

a) Manual block and by-pass
b) Duplicate, parallel, control valves where manual control is considered impractical.

13.6.7 All valves shall be fitted with corrosion proof label marked with item and tag number.

13.6.8 Where the size of a control valve has an influence of the capacity of relief valves it shall carry a warning label. The inscription shall state: -

WARNING
TRIM SIZE AFFECTS RELIEF VALVE CAPACITY

Such valves shall have full size trims and shall not be equipped with limit stops.

13.6.9 Specified accessories shall be piped in 316 SS tubing, ¼" or ½" od as applicable. Copper tubing shall not be used.

13.6.10 All accessories shall be fully mounted/piped/wired as part of the valve assembly and shall be suitably terminated.

13.6.11 Sunshades shall be fitted to control valves, to cover electrical / electronic components.

13.7 Definition of Severe Service Application

Control valves in severe services include the applications in the following paragraphs.

Valve outlet pressure drops less than 50% of inlet pressure
Calculated A-weighted sound pressure level (SPL) emission exceeding 85 dB(A) for an specified flow conditions excluding any corrections for path treatment
Trim, Actuator, Gasket Packing requires specific design as operating system pressure is high, P1 ANSI #900
Special trim design is required with high range ability due to the operating condition of Minimum and Maximum (normally 50:1 and higher)
Valve operated under flashing condition where outlet pressure (P2) is lower than the vapor pressure
All services for which the system application cavitation index Ksa exceeds 0.8 for any Specified flow conditions (Ksa > 0.8)

Ksa, the system application cavitation index, is defined as Ksa = (P1-P2) / (P1-Pv) where pressures are expressed in absolute units

Vendor shall submit the following calculation sheets, for each valve.

Calculation Sheet	Required For
Cv calculation including noise calculation	All control valves
Trim exit velocity calculation	All control valves

13.8 Valve Trim Design

13.8.1 Sizing calculation shall comply with ISA S75.01, "Flow Equations for Sizing Control Valves".

13.8.2 For Liquid flow, the trim exit velocity shall not exceed 30 m/s (100 ft/s) for single phase liquid. For flashing service, the trim exit velocity limit is 23 m/s (75 ft/s) maximum.

13.8.3 For Gas and Stream flow, the velocity head in the trim outlet shall be less than 70 psi (480 kPa) in order to eliminate vibration and erosion. Valve trim exit velocity shall be calculated based on ISA publication "Control Valves, Practical Guides for Measurement and Control". Velocity head is expressed as follows:

$$\text{Velocity Head } V_h = \frac{\text{Density} \times V^2}{2 \times g_c}$$

where: Density = valve trim exit fluid density
V = valve trim exit fluid velocity
g_c= gravitational constant in unit of measurement

13.8.4 Vendor shall provide calculations demonstrating required number of pressure reducing stages to satisfactorily comply with the above velocity limit.

13.8.5 Vendor shall provide sufficient number of discrete pressure stages to ensure elimination of vibration, erosion and cavitation. Vendor shall specify the number of stages in the proposal.

13.9 Noise

13.9.1 Vendor shall provide noise calculations with his bid in accordance with methodology outlined in ISA SP75.17 and IEC 534-8-3 guidelines.

13.9.2 Control valve noise shall be treated at the source by multi-path, multi-stage velocity control trim design. Any diffusers, baffle plates or downstream devices either inside the valve body or downstream of the valve, shall not be used.

13.9.3 All noise levels specified by vendor shall be based without any thermal or acoustic padding on the downstream pipe.

13.9.4 The maximum allowable noise level shall not exceed 85dBA with zero tolerance in the calculations. Noise calculations shall be based on 1 meter downstream of the valve and 1 meter from the pipe surface. Vendors are required to include inaccuracies of their calculated noise levels and shall guarantee that the noise emission from the control valve, including upper tolerance, shall not exceed the above stated limits for any specified operating condition.

14.0 Emergency Shutdown System (ESD)

The ESD shall be designed to drive the plant to a safe condition in the event of abnormal operating conditions, equipment failure, gas leaks, fire or manual intervention via shutdown switches.

ESD shall be designed according to the requirement of IEC 61508. The contractor shall perform safety life cycle analysis per the requirement in the IEC 61508. The contractor shall submit this document to PTT to review and approval for each step before proceeding with the next one.

Each Safety Function shall be allocated a Safety Integrity Level (SIL) and the system architecture and components designed to meet the allocated SIL. A specific SIL review shall be undertaken to allocate SIL's to each safety function and shall be based on the demand frequency and consequences of failure of the safety function. A Reliability Calculations report shall be provided to demonstrate the achievement of the required SIL. The SIL calculation shall be based on MTTR 8 hours and 1 year online testing interval. CONTRACTOR shall provide detailed test procedures covering the routine testing required during the life cycle of the PLANT to maintain the required SIL for each Safety Function.

14.2 The protective system shall be designed in accordance with Engineering Standard ES-60.02.

14.3 The protective instrument systems will consist of TUV certified critical transmitter, logic solver and final element. For the shutdown valve used for final element, partial stroking test feature shall be provided.

14.4 Racks and cubicles for alarm, interlocking and shutdown systems shall be located in the Rack Room.

14.5 For shutdown functions, separate independent sensors shall be used with separate process tapping points and separate wiring to the shutdown system.

14.6 Systems shall be designed to be fail-safe:

- Pneumatically operated shutdown valves shall move to their safe position on air failure

- Solenoid valves shall be normally energised, de-energised to trip.

The system shall be designed to ensure that parallel process units or equipment do not trip simultaneously in the event of system failure.

14.7 Final shutdown valves shall not be provided with hand-wheels or by-pass facilities.

15.0 ANALYSERS AND SAMPLING SYSTEMS

15.1 Analysers and sample systems shall be designed in accordance with Engineering Standard ES-60.08.

15.2 Analysers shall generally be installed in a purpose-built prefabricated analyser house, designed in accordance with ES-60.07.

16.0 DESIGN REQUIREMENT FOR PRESSURE RELIEF VALVES

16.1 General

16.1.1 Relief valves shall be designed, including external dimensions, in accordance with API Std 526.

16.1.2 Seat tightness shall be in accordance with API Std 527.

16.1.3 Relief valves shall be installed in accordance with API RP 520.

16.2 Sizing

16.2.1 Relief valves shall be sized in accordance with the following basis: -

Gas and Vapour Service Codes

ASME I for Fired Vessels.
ASME VIII for Unfired Vessels.

Liquid Service

API RP 520, using the Liquid "Certified" formula.

16.3 Conventional Type

16.3.1 Conventional type pressure relief valves shall only be used where the backpressure is substantially constant e.g. atmospheric relief or high set pressures.

16.3.2 Conventional type relief valves shall be of the nozzle entry type having enclosed springs and conforming to API Std. 526 except for steam or hot condensate when open bonnets shall be used.

16.3.3 Bodies shall be carbon or alloy steel and trims 12% Cr alloy or other suitable corrosion resistant alloy.

16.3.4 For flammable or toxic service, bonnets shall be vented to the discharge side of valve.

16.4 Balanced Type

16.4.1 Balanced type relief valves shall be used where backpressure conditions preclude the use of a conventional type. All designs (piston type, bellows type etc.) may be considered.

16.4.2 Balanced type shall be used for constant or variable backpressure.

16.4.3 Bonnet and bellows vent shall be routed with minimum restriction to a safe location. In bellows type pressure relief valves, bonnet shall be vented separately from discharge.

16.4.4 Bellows type valves shall not be used in fouling conditions.

16.4.5 Auxiliary balancing piston type shall be used for critical and fouling services.

16.5 Pilot Operated Type

16.5.1 A pilot assisted pressure relief valve is preferred to a pilot operated valve.

16.5.2 Pilot assisted valves shall be used where the operating pressure approaches the set pressure.

16.5.3 The use of snap acting or modulating pilots may be considered.

16.5.4 Non flowing pilots shall be considered for corrosive services

16.5.5 Pilot assisted valves shall be considered where accuracy or rapid opening and closing are required.

16.5.6 Pilot operated relief valves shall not be used in fouling or high temperature service.

17.0 INSTRUMENT/ELECTRICAL INTERFACE

17.1 Interface between control systems and switchgear shall be via interposing relays mounted in separate interface cabinets.

17.2 For start/stop/trip of motors, the relays shall have 24V dc coils energised by the control system as follows:

Motor Start	-	N/O contact, energise to start (2 sec pulse)
Motor Stop	-	N/O contact, normally energised coil, de-energise to stop (2 sec pulse)
Motor Trip	-	Separate N/O contact, normally energised by ESD system, de-energise to stop (2 sec pulse)

17.3 For status indication, the switchgear shall provide volt-free contacts to the control system wired via the E/I interface cabinet.

Motor running	-	N/O contact, close on run
Motor stopped	-	N/O contact, close on stopped
Alarm	-	N/C contact, open on alarm

The extent of control and indication of motors and switchgear shall be as shown on the P&ID.

18.0 ALARM SYSTEMS

18.1 All abnormal conditions shall be visible in the main control room. The extent of such alarms shall be in accordance with the P&IDs.

18.2 Alarms shall be initiated by the opening of a contact. Alarm contacts shall be closed in normal operating conditions.

18.3 Where alarm conditions exist temporarily the alarm shall remain visible until acknowledgement.

18.4 Attention to alarm conditions shall be drawn by flashing lamps, displays or buttons. Where practicable the visual alarm shall be accompanied by an audible alarm.

18.5 Where one abnormal condition may result in a rapid sequence of events a 'first-up' alarm sequence shall be applied.

18.6 The DCS shall display its own system fault alarms, process alarms and pre-trip alarms

18.7 Where the status of trip initiators and activators, plus other static information, is exclusively repeated to the DCS for operating purposes the DCS may be employed exclusively for all relevant alarms.

18.8 All alarms routed to the main control room shall be logged

18.9 On Packaged Units, including rotating machinery, all alarms shall be indicated on a local annunciator panel, with a common fault alarm and trip alarm routed to the main control room. 'Reflash' facilities shall be provided for all common alarms.

18.10 Where a hard-wired annunciator is employed the alarm logic shall be based on solid state plug in cards. Isolation shall be provided for each associated field circuit, plus over-current protection.

18.11 Each annunciator panel shall be provided with 'Acknowledge' and 'Lamp Test' facilities, plus a 'Reset' facility where applicable.

19.0 FIRE AND GAS SYSTEMS

19.1 The Fire and Gas System is described in Engineering Standard ES-90.03.

19.2 The Fire and Gas detection and alarm system shall be functionally independent from the DCS. The system will consist of three parts,

19.2.1 The Gas Detection System

19.2.2 The Fire alarm system, including manual call points and CO2 purge system.

19.2.3 The Water Deluge control system

19.3 Alarms, indications and manual controls for the Fire and Gas systems shall be located in the Control Room. These will be included on a hard-wired mimic panel.

19.4 The main fire and gas panels shall be located in the control room. Common alarms shall be relayed to the central control room.

19.5 The Fire and Gas system shall be of the normally de-energised design.

20.0 REFERENCED ENGINEERING STANDARDS

ES-50.02	Piping Material Standard
ES-60.02	Emergency Shutdown System Standard
ES-60.03	Package Instrument Specification
ES-60.05	Distributed Control System Standard
ES-60.06	Instrument Installation Specification
ES-60.07	Analyser Houses Standard

ES-60.08	Analyser Sampling Systems Standard
ES-60.09	Metering System FDS
ES-91.01	Equipment Noise Standard
ES-92.06	Protective Coatings
ES-99.00.05	Basic Engineering Design Data (BEDD)
ES-99.01	Equipment numbering system

21.0 REFERENCED NATIONAL STANDARDS

AGA Report N°. 3	Orifice flow meters for gas measurement
AGA Report N°. 7	Turbine meters for gas flow measurement
AGA Report N°. 11	Measurement of Natural Gas by Coriolis Meter
ASME I	Power Boilers (Relief Valves)
ASME VIII	Unfired Pressure Vessels.
ASME PTC 19.3	Temperature measurement (vibration calculations)
ANSI/ASME B40.1	Gauges and Pressure Indicating Dial Type, Elastic Element.
ANSI/ASME B16.36	Orifice flanges
ANSI B16.5	Pipe Flanges and Flanged Fittings.
ANSI B16.10	Valves
ANSI FCI.70-2	Control Valve Seat Leakage.
API 6F	Fire test for Valves
API RP520 Part 1 & 11	Design and Installation of Pressure Relieving Systems in Refineries.
API Std 526	Flanged Steel Safety Relief Valves.
API Std 527	Commercial Seat Tightness of Safety Relief Valves with metal-to-metal seats.
API RP551	Process Measurement Instrumentation
IEC 60584-1	Thermocouples
IEC 60751	Industrial Platinum Resistance Thermometer Sensors
ISA-75.01	Control Valve sizing equations
ISO 5167 Part 2	Orifice Plate
NACE MR-01-75	Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment
IEC 61508	Functional safety of electrical/ electronic/ programmable electronic safety-related systems

IEC 61511	Functional Safety: Safety Instrumented Systems for the Process Industry Secto

REVISION	REV 01	REV 02	REV 03	REV 04	REV 05
DATE	Jan 2005				
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SIGNATURE					

CONTENTS

1.0 SCOPE

This specification describes the practices that shall be employed and the standards of workmanship that will be required for the installation of instrumentation.

2.0 SPECIFICATIONS STANDARDS AND CODES

2.1 Specifications

The following specifications are applicable:

ES-60.01	Instrumentation General Specification

2.2 Standards and Codes

The Installation shall generally be in accordance with API recommended practices and ISA standards:

API RP 540	Electrical Installations in Petroleum Processing Plants
ANSI/NFPA 70	Wiring Practices
NEC	Wiring Practices
ANSI/ISA-RP12.6	Wiring Practices for Hazardous (Classified) locations, Instrumentation, Part 1: Intrinsic safety
BS6121 part 1	Mechanical cable glands

Control of Substances Hazardous to Health (COSHH) regulations

3.0 GENERAL REQUIREMENTS

3.1 General

The detailed range of instrument installation activities, together with Bills of Quantities and applicable drawings will be defined in the Sub-Contract Requisition.

Quality Assurance, Inspection and Testing shall be undertaken in accordance with Installation CONTRACTOR's Quality Assurance System / Quality Plan, requirements of the PROJECT SPECIFICATION and referenced International Codes and Standards.

Instruments and/or materials shall be purchased from the list of approved VENDORs, as supplied in the PROJECT SPECIFICATION.

Attention shall be given during construction to the protection of equipment against general construction site hazards and in particular the protection of equipment from the weather. Instruments and panels that cannot be installed upon delivery should be housed in a properly constructed and temperature controlled store, protected from dust and damp. Throughout the construction period, instruments that are not provided with housings shall be protected by covering with heavy duty plastic bags or where necessary by applying more robust protection.

4.0 INSTRUMENT LOCATION AND SUPPORT

4.1 General

Instruments shall be located in accordance with the detail drawings and with due regard to accessibility and maintenance activities. Vents, drains and filling points shall be sited to minimise the impingement of process fluids on instrument equipment and cables.

Care shall be taken to ensure that no passageways or access to equipment are obstructed. Instruments shall be clear of drainage points for condensate, water and process fluids from adjacent equipment. Instruments shall be located away from potential fire risks, spillage areas, hot environments, and sources of radiation. Indicating instruments shall be orientated to permit viewing from walkways or platforms. Instruments shall be accessible for adjustment or maintenance without the use of ladders or staging, except as defined in paragraph 4.2.1.

Instrumentation requiring operator access shall be mounted at a height of 1400mm from grade or platform. Other instrumentation shall also be mounted at 1400mm from grade or platform.

The only permitted exception to the above is for DP level transmitters where the preferred installation is level with the bottom vessel connection and as such may be less than 1400mm above platforms. Direct connected devices such as level switches, displacers, thermowells, etc., have their elevations fixed by their respective process connections.

Where field indicators are specified in association with blind transmitters, the field indicator shall be located so as to be visible from the associated control valve or final element, unless otherwise noted on the P & I diagrams or instrument location plans.

When installing instruments, allowance shall be made where necessary for any tracing, insulation and housings which may be required.

A clearance of not less than 300mm is required between any hot surface (temperature in excess of 65^{o}C) and any plastic air tubing, instrument process piping, or analyser sample system tubing.

No instrument support shall be welded to a vessel, pipe or any other equipment containing process fluids. The only exception to this shall be for instrument supports/brackets installed by vessel fabricator at his works as part of the vessel dressing.

With the exception of pressure gauges no instrument shall be installed such that it depends for support or rigidity on the impulse piping.

Pressure gauges shall be installed such that their blowout protectors are not obstructed. Protectors shall face away from the operator. The minimum clearance between blowout disc and a nearby obstruction shall be 25mm.

Handrails shall not be used for mounting or supporting instruments, nor shall any instrument or support be located within 150mm of the top handrail.

Special attention shall be paid to the mounting of instruments with filled systems and capillaries. Capillary tubing shall be adequately supported and protected against mechanical damage and shall be run independently of all other lines. Extra lengths of capillary shall be coiled up at the instrument end, with a minimum bending radius of 125mm.

Instruments fitted with direct mounted manifolds shall be supported by the manifold and not by the instrument.

Instrument field supports, junction box frames, etc shall be prepared and finished in accordance with detail drawings. Minor brackets and supports of mild steel construction shall be galvanised.

All instrument equipment shall be mounted and supported such that it is free from vibration and misalignment.

All protective finishes shall be in accordance with Engineering Standard ES-92-06. CONTRACTOR will be continuously monitored to ensure correct techniques are followed.

All local panels, JB frames, etc shall be levelled using shims as required. Where equipment is mounted at grade, the supports shall be grouted such that any water is shed.

4.2 Instrument Accessibility

4.2.1 General

All instrument equipment shall be accessible for servicing from floor level, walkways, permanent ladders or platforms. Orifice plates, thermocouples and other in-line devices may be accessed by temporary means if they are less than 4m above floor level. Above 4m they shall be provided with permanent access.

4.2.2 Access from a Platform

To be accessible from a platform the location must satisfy the following:

a) The equipment shall be located on, next to, or above a platform.
b) When the equipment is located next to a platform, the centre of the operating mechanism shall not be more than 0.5m outside the handrail and not more than 1.5m nor less than 150mm above the platform.
c) When the equipment is located above a platform, the top of the mechanism shall be not more than 2.1m nor less than 150mm above the platform.

4.2.3 Access from a permanent ladder

To be accessible from a permanent ladder the equipment shall not be more than 1m from the centreline of the ladder.

5.0 INSTRUMENT PROCESS PIPING AND TUBING

5.1 General

All instrument process piping, fitting and tubing shall be 316 stainless steel as a minimum. Actual material specification shall be in accordance with the project piping material specification. All valve ,fittings and tubing shall be “Swagelock”.

All impulse lines shall be run with a slope of not less than 1:12. The slope shall be down from the tapping point for liquid, steam and condensibles and up from the tapping point for gases in accordance with detail drawings.

Vents shall be sited at the highest point of the installation and drains at the lowest.

Impulse lines shall be kept as short as possible consistent with good practice and accessibility.

Joints made in adjoining tubing lines shall be located such that the joints are not adjacent at the same level.

Tubing shall not sag. Adequate support shall be provided.

Tubing shall be run with minimum number of changes of direction consistent with good practice and neat appearance.

Tubing or piping shall not be supported from handrails.

Tubing shall not be supported from process lines except by agreement with the site engineer.

Steel piping shall be jointed with approved fittings as specified on the drawings. Where practicable, pulled bends shall be used in preference to fittings.

Due regard shall be given to hot service installation that is subject to contraction, to ensure that sufficient flexibility is allowed.

Stainless steel pipes or tubes shall not be located where, in the event of a fire, there is a possibility of molten zinc falling onto the stainless steel from associated galvanised structures, zinc chromate paint, etc. This is necessary to eliminate the dangers caused by zinc embrittlement of stainless steel.

Stainless steel tubing with compression fittings shall be installed as specified by the fittings manufacturer. This shall include, but not be limited to, the following:-

- Proper cutting of the tube. Only approved cutting tools shall be used.
- Proper installation of the ferrules.
- Checking that the tube is round and free from burrs and distortions.
- Correct level of tightening of fittings without over-tightening.

6.0 INSTRUMENT AIR PIPING

6.1 General

The location of the main instrument air headers and the take off points shall be as shown on the drawings.

Instrument air manifolds will normally be used in areas of high user density. Where instrument density is low, spider type air header should be used.

Air supply headers shall be sized as follows:

1-5 users - ½" NB
6-20 users - 1" NB

All branch take-offs shall be from the top of the header.

All take-offs from the main air header shall have an isolation valve. Take-offs shall be spaced at 10m intervals along headers and sub-headers.

The detailed routing of all sub header pipework shall be responsibility of the Installation CONTRACTOR.

CONTRACTOR shall ensure that drain legs are supplied at each low point of the installation.

7.0 INSTRUMENT AIR SIGNAL TUBING

7.1 <u>General</u>

Tubing shall be jointed only with approved compression fittings compatible with the tube material. All tubing shall, as a minimum be of ¼" or ½" 316 stainless steel. All fittings shall be "Swagelock".

Where required, a minimum amount of liquid sealant may be used. Care must be taken to ensure that there is no intrusion of sealant into the line. PTFE tape shall not be used.

All tubing shall be cleaned by blowing through with filtered air before connecting to instruments.

Sufficient slack shall be allowed in all air tubing to avoid strain on the instrument connections. Connections to instruments shall have sufficient flexibility to facilitate disconnection. All control valves and vessel mounted transmitters shall have an extra 150mm diameter loop in their air tubings for maximum flexibility.

8.0 PIPING AND TUBING SUPPORTS

8.1 <u>General</u>

Tubing shall not be fastened directly to process lines or other process equipment. Vibrating structures and equipment shall be avoided.

One or two single pipes or tubes may be supported by dedicated heavy duty channel section if other support is not available.

The length of unsupported tubing to final destination (such as control valve or transmitter) for single tubes shall not exceed 0.5m.

Tubing shall be fastened to support at regular intervals with non corrosive fixings to prevent sagging, or misalignment.

Where three or more single tubes are run parallel to each other, galvanised mild steel cable tray, as used for instrument cables, shall be used for support.

Care shall be taken to avoid stainless steel tubing coming into direct contact with galvanised supports.

9.0 INSTRUMENT CABLING

9.1 General

Instrument cabling shall be installed in such a manner that the design requirements for the contract in terms of safety, reliability, access, etc are realised. The main points of the design philosophy are given below and all installation methods shall take account of this philosophy.

9.2 Design Philosophy

9.2.1 All outdoor cables shall be armoured. All cables shall be supplied as specified in agreed project cable specification.

9.2.2 Multicore cables shall be sized such that they contain a minimum of 20% spare conductors at the completion of contract design

9.2.3 Junction boxes shall be dedicated to one signal category only.

9.2.4 Intrinsically safe circuits and non-intrinsically safe circuits shall not be contained within the same cable or marshalled in the same junction box.

9.2.5 Earthing shall be as shown in the "Instrument Earthing Philosophy" drawing. This drawing gives details of all earthing required and incorporates the following general principles:-

i) All equipment containing an electrical signal or power supply shall be earthed for personnel safety reasons and for minimising electrical interference. This includes enclosures, cable, cable tray and conduit.

ii) Cable screens shall be electrically continuous throughout the cable run and shall be earthed at one point only. This point is normally the panel reference bar of the panel or cabinet to which the cable is connected. It is always shown on the detailed drawings.

iii) The design of the earthing system shall avoid the creation of earth loops caused by duplication of earthing paths. Particular attention shall be paid to the isolation of panel reference bars within panels and cabinets and their final earthing to a point of zero potential.

9.2.6 All cabling shall be protected against mechanical damage, chemicals and heat. In general, underground cabling and cabling run on ladder rack and tray will meet these requirements if installed in accordance with the Contract drawings and provided attention is paid to detail routing.

9.3 Field Cable and Junction Box Numbering

9.3.1 The number of every cable and junction box is shown on the detail drawings.

9.3.2 Main cable numbers shall consist of a prefix defining the signal category followed by a sequential number.

9.3.3 Main junction box number is derived from the main cable number prefixed JB.

9.3.4 Secondary multicores (ie. multicores between the main JB and secondary JB) are derived from the main cable number with a suffix letter.

9.3.5 Secondary junction box number is derived from the secondary multicore number prefixed JB.

9.3.6 Secondary cable number from JB to individual instrument is derived from the main cable number with a 2 digit suffix corresponding to the pair number in the main cable, or by the instrument tag number.

9.3.7 The system described above is modified slightly when 2 main cables are run to the main junction box. In this case the main cables are suffixed A & B. Any secondary multicores carry a further suffix. Secondary cables are numbered as though the 2 main multicores were one larger cable.

9.3.8 Cable numbers other than those connected to JBs use the system described above for main cable numbers (paragraph 9.3.2) but the sequential number is taken from a different series.

9.4 Control Room Cable and Junction Box Numbering

9.4.1 Control room cables are numbered as described in paragraph 9.3.2. using a separate series of sequential numbers.

9.4.2 Junction box numbers (where required) are derived as described in paragraph 9.3.3.

9.4.3 The secondary cable numbering system (see paragraph 9.3.6) is not used in control rooms.

9.5 Cable Separation

9.5.1 Main cable routes are shown on detail drawings and these take account of the segregation requirements. These requirements are given below and must be adhered to for all cable routes not detailed elsewhere.

9.5.2 Instrument cables shall be routed separately from electrical power cables. The physical separation of signal and power cables on parallel runs shall be as below:

Power Wiring Capacity	Minimum Separation (mm)
125V or 10A	250
250V or 50A	500
440V or 200A	750
3.3KV or 500A	1250
11KV up or 800A	4000

9.5.3 Crossovers that bring signal and power cables into close proximity shall be made at right angles. The minimum separation at the point of crossover is 250mm.

9.5.4 The requirements described above may be relaxed at entries to instruments and panels.

9.5.5 Instrument cables carrying more than 10 amps shall be treated as power cables.

9.5.6 Instrument power cables, above 115VAC should not be run with instrument signal cables.

9.5.7 On tray routes instrument power cables shall be run on separate tray.

9.5.8 Instrument signals are divided into different categories and these categories shall be grouped together.

9.5.9 I.S. and non-I.S. cables may be run together in the same tray but shall be separated into different bundles.

9.6 Cable Installation

9.6.1 All cables from control buildings to junction boxes, from junction boxes to individual instruments, and other cables, shall be supported by a suitable cable support system. Ladder rack shall be used for the larger routes and cable tray for the smaller (below approx 200mm width). The main cable rack routes shall run on the top level of the pipe racks, shall be hot dipped galvanised steel and be furnished with covers.

9.6.2 The following general requirements are applicable to all above ground cable installations:

Ladder rack and cable tray shall be heavy duty, galvanised mild steel. They shall incorporate return flanges for personnel and cable protection and additional strength. They shall be equally suitable for use in the field or in buildings.

Ladder rack shall be capable of spanning a 6 metre length if necessary and must be capable of supporting a point load of 100Kg at mid-span over a 5 span continuous run, in addition to the calculated distributed load. Tray shall be capable of spanning a 2 metre length unsupported. Longer lengths of tray may be braced using longitudinal channel section.

Supports for ladder rack and tray shall be supplied by the ladder rack or tray manufacturer and shall be adjustable for ease of installation. All supports and jointing fittings shall be heavy duty, mild steel galvanised. Unprotected supports shall be painted prior to cable installation.

Supports for ladder rack and tray shall be fixed to suitable structural steel or concrete, before the application of any fireproofing. Welding is the preferred method of fixing to structural steel. Galvanising shall be repaired after welding. Supports shall not be welded to vessels or pipework.

Where site fabricated bends are used, they shall conform to the minimum bending radius recommended by the cable manufacturer.

Cables may be stacked 2 high (max) on ladder and tray installations. Spare capacity should be provided on all installations (1 additional cable or 20% of total number, whichever is greater).

Tray and ladder routes shall avoid obstructions, hot surfaces, vibrations and areas of high ambient temperature. Minimum clearance from hot surface (above 65^{o}C) shall be 300mm. The route shall not run beneath parallel runs of process piping and shall not block walkways or access to equipment.

Routes which cross walkways shall provide a minimum headroom of 2 metres. Routes which cross roads or areas requiring vehicular access shall provide a minimum headroom of 5.5 metres.

Where routes pass through the floor of a structure, mechanical protection in the form of a metal sleeve or kickplate shall be provided. This shall project a minimum of 75mm above floor level.

Cable tray should only be cut along a line of metal i.e. not through the perforations. Holes cut in tray for the passage of cables shall be bushed or lined to avoid cable damage.

Individual cable runs near to the final termination point, such as an individual instrument, should be run in galvanised mild steel angle or proprietary channel section. Closed conduit shall not be used.

Cable separation (see paragraph 9.5) shall be maintained in above ground cable installations. This may require the use of separate trays for different signal groups. Instrument power cables shall not be run on the same tray as signal cables.

9.7 Cable Installation Inside Buildings

9.7.1 Cables within control rooms will normally be routed underfloor. Where cables are routed above the floor they shall be in trunking or conduit.

9.7.2 The following general requirements are applicable to cable routes inside buildings.

Underfloor cables shall be installed on ladder rack and cable tray. The general requirements for above ground installations in the field are applicable.

Above floor routes of trunking and cable tray should also be installed in accordance with these general requirements. Flexible conduit may be used for runs from main trunking to final termination point. Trunking shall be provided with drain holes in areas where condensation may be experienced.

Conduit shall be free from burrs and shall be fitted with locknuts, bushes and ferrules at termination points. Conduit shall be neatly run and adequately supported. PVC conduit shall avoid equipment operating at elevated temperatures.

9.8 Fire Hazards

9.8.1 All cables shall be supplied with a fire resistant outer sheath.

9.8.2 Where an unavoidable fire hazard exists the complete cable installation shall be protected by enclosing in a thermal insulating material. The extent of protection will be shown on the detail drawings.

9.9 Cable Entry to Buildings

9.9.1 Cable entry to all buildings is via a proprietary cable transit system.

9.9.2 Building penetrations shall be sealed after installation of cables.

9.10 Cable Installation - General

9.10.1 Cables shall only be terminated in instruments, junction boxes or other approved equipment. No intermediate cable joints are permitted.

9.10.2 Where cables are pulled prior to installation of package units, modules, etc, care shall be taken to ensure that cables are adequately protected.

9.10.3 When installing cables the radius of all bends shall exceed the minimum bending radius specified by the cable manufacturer.

9.10.4 Instrument cables shall not be run on the same tray as instrument piping and tubing.

9.10.5 Installation, terminating, jointing and testing of fibre-optic and co-axial cabling shall be strictly in accordance with the manufacturer's instructions.

9.10.6 Above ground cables shall be fixed using pre-formed saddles or PVC covered stainless steel strapping. PVC cable ties shall not be used. Cables shall be fixed at approximately 250mm intervals in vertical runs and 500mm intervals on horizontal runs.

9.10.7 Cables connected to instruments shall be installed with a loop of cable to provide sufficient slack for re-making the cable connection if the instrument is removed and to allow for removing the instrument without electrical disconnection.

9.11 Cable Glanding

9.11.1 All cables in the field shall be glanded with correctly certified cable glands in accordance with the hazardous area classification.

9.11.2 Cable glands are not normally required for cables in equipment rooms of buildings, but may be required at other locations within buildings.

9.11.3 The following general requirements are applicable to all gland installations:-

Cable glands shall comply with BS6121 part 1.

All gland installations shall maintain the IP rating of the associated equipment.

The gland thread shall match that of the associated equipment wherever possible. The use of thread adaptors shall be minimised.

Cable glands in the field shall be protected by fitting PCP shrouds.

9.11.4 All glands shall be fitted in the bottom of equipment located in the field. Side entry is permitted but top gland plates shall not be used.

9.11.5 Particular attention shall be given to the manufacturers installation instructions to ensure that the gland installation does not detract from the ingress protection rating of the enclosure onto which it is installed.

9.12 <u>Cable and JB Marking</u>

9.12.1 Every instrument cable and junction box is allocated a number. These numbers shall be marked on the cables and junction boxes.

9.12.2 Cables shall be marked at the entry point to each cabinet, junction box, instrument or other equipment item and on both sides of transit entries into buildings. All cables inside buildings shall be marked including control network cables. Cables shall be marked using a suitable plastic marker and carrier system.

9.12.3 Junction boxes shall be identified by means of an engraved label. Normal background colour shall be white.

For junction boxes on shutdown service the background colour shall be red and a further label shall be fitted stating "This box contains trip circuits".

For intrinsically safe junction boxes the background colour shall be blue and a further label shall be fitted stating "This box contains I.S. circuits".

9.13 <u>Wiring Terminations</u>

9.13.1 Wiring terminations shall be in accordance with the following general requirements:

All terminals shall be screw clamp type where the screw is not in direct contact with the wire. Terminals may incorporate test sockets if necessary. Power supply terminals and all terminals with voltages over 50V shall be fitted with protective covers and warning labels. Power supply terminals shall be fitted with partitions between adjacent terminals.

Solid conductors shall not be fitted with crimped connections. Stranded conductors shall be crimped using a crimp that also grips the insulation of the conductor. The termination end of the crimp shall be suitable for the terminal to which it is connected. All crimping shall be carried out using the crimp manufacturer's approved tool.

Normally only one conductor shall be terminated in each terminal. Common connections shall be made as far as possible using the terminal manufacturer's standard bridging arrangement. Where connection of 2 wires into one terminal is unavoidable, two flat-bladed crimps shall be used. Two wires shall not be crimped in one crimp sleeve and two round-pin type crimps shall not be screwed into one terminal.

Sufficient slack wire shall be left looped at terminals to allow for re-making of terminations.

All spare cores in multicore cables shall be terminated. Sufficient terminals shall be fitted in all equipment to facilitate this.

Conductors shall be ferruled with the number of the terminal to which they are connected.

10.0 LABELS

10.1 Every item of instrument equipment for which an identification reference is allocated shall be provided with an engraved label. This label will be in addition to any manufacturer's wired-on tags or nameplates.

10.2 Labels will normally be engraved plastic. Dimensions, sizes, colours, engraving details and method of fixing shall be as determined by the contract drawings or as agreed with the site engineer. Information for labels (ie. tag number and service) is as given in the contract drawings.

10.3 Labels for individual instruments shall be fitted adjacent to the instrument such that the label remains in place if the instrument is removed. Labels for other equipment shall normally be fitted on the equipment.

10.4 Further Labels shall be provided as required on detail drawings or as agreed with the site engineer. These will include, but may not be limited to, the following:

Warning Labels Instructions

REVISION	REV 01	REV 02	REV 03	REV 04	REV 05
DATE	Sep 2005				
ORIG.BY	AGK				
APP.BY	BDS				
SIGNATURE					

CONTENTS

SECTION SUBJECT

SECTION III 0.6/1 KV ARMORED CABLE WITH SHIELD

SECTION IV 0.6 KV ARMORED CABLE

SECTION I INSTRUMENT CABLE

1. SCOPE

This specification defines the minimum requirements for the design, manufacture, inspection, testing. packing and shipping of Instrumentation Cables.

Plant instrumentation cables are categorized as follows:

- Signal cables for general instrumentation.
- Signal cables for Foundation Fieldbus
- Signal cables for fire and gas detection service and Plant communication.
- Cables for instrumentation power signals.
- Cables for fire and general alarm protection service.
- Thermocouple cables.
- Computer and data transmission cables.
- Fiber optic cables.
- Grounding cables

2. DEFINITIONS

Company	:	PTT (PTT Public Company Limited)
Contractor	:	The party that carries out all or part of the EPCC contract.
Purchaser	:	Company or Contractor as specified in the covering letter of the inquiry document.
Vendor	:	Manufacturer/Supplier/Vendor is the party that manufactures or supplies equipment and services to perform the duties specified by the Purchaser.

3. APPLICABLE CODES, STANDARDS AND REGULATIONS

The applicable sections, latest editions and supplements of the following codes, standards and regulations, unless modified herein, shall constitute minimum requirements and form part of this specification:

IEC 60228	-	Conductors of insulated cables.
IEC 60228A	-	First supplement: Guide to the dimensional limits of circular conductors.
IEC 60331	-	Fire-resisting characteristics of electric cables.
IEC 60332 Part 3	-	Tests on electric cables under fire conditions.
IEC 60502	-	Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV.
IEC 60540	-	Test methods for insulation and sheaths of electric cables and cords (elastomeric and thermoplastic compounds).
IEC 60754	-	Tests on gases evolved during combustion of electric cables.
IEC 60811	-	Common test methods for insulating and sheathing materials of electric cables.
IEC 60815	-	Electrical test methods for electrical cables.
IEC 60815-2 Part 2	-	Partial discharge tests.
BS 5308	-	Instrumentation cables.
BS 4066 Part 3	-	Test on electric cable under fire conditions: Method of classification of flame propagation characteristics of bunched cables.
BS 5467	-	Cables with thermosetting insulation for electricity supply for rated voltages up to and including 1900/3300 V.
BS 6004	-	PVC insulated cables (non-armoured) for electric power and lighting.
BS 6360	-	Conductors in insulated cables and cords.

BS 6469	-	Methods of test for insulation and sheaths of electric cables.
BS 6387	-	Performance requirements for cables required to maintain circuit integrity under fire conditions.
BS 6622	-	Cables with extruded cross-linked polyethylene or ethylene-propylene rubber insulation for rated voltages from 3600/6600 V up to 19000/33000 V.
BS 6746	-	PVC insulation and sheath of electric cables.

Any conflict between this specification and referenced documents shall be brought to the attention of the Company in writing for resolution. In general, the order of precedence is:

- Thai national laws, statutory and local authority regulations.
- This specification.
- Referenced codes and standards.

Compliance with this specification does not relieve the Contractor of the responsibility of supplying cables of proper design and construction and full suitability for all the specified operating conditions.

4. DESIGN DATA

4.1 Environmental Conditions

The electrical cables shall be suitable for use in the site environmental conditions as detailed in 'Basis of Design'.

5. MATERIALS AND DESIGN

Materials shall be new and of high quality. Cables offered must be of current proven design. Prototype materials and designs are not acceptable.

6. TECHNICAL REQUIREMENTS

6.1 Instrumentation Cables

All instrumentation cables shall be suitable for outdoor tropical service in a salt-laden environment gas process plant, with heavy rains, intense sunlight and high ambient temperature and up to 100% relative humidity. All instrumentation cables shall be oil, moisture, UV resistant, anti-termite, anti-vermin and flame retardant and shall be suitable for a 20 year service life.

6.1.1 Signal Cables for General Instrumentation

Cables for low level 4-20 mA signals to/from field transmitters, control valve positioners, mV level signals from proximity and vibration sensors, electronic level binary status signals for general field instrumentation, including interpanel signals, shall be of the type described in this section.

Cables shall be 300/500 V comply to

STANDARD APPLICABLE

BS 5308-1	Design Guideline
BS 6360	Conductor
IEC 60332-1	Flame Retardant
IEC 60332-3C	Fire Retardant on Bunched Cables (If required)
BS1442	Specification for Galvanized mild steel wire for Armouring Cables
IEC 60754	Halogen free properties
IEC 61034	Low smoke emission

Detailed specification shall be as below:

Conductors	Anneal Copper Wires according to Class 1 or 2 or 5 of BS 6360
Insulation	XLPE in accordance with IEC 60502
Pairs	Twisted
Assembly	Concentric Layers

Overall Screen	Aluminium / Polyester tape 0.024 mm in electrical contact with tinned annealed copper wires of a total section of 0.5 mm^2 polyester tape 0.023 mm
Bedding	LSOH thermoplastic compound
Chemical & moisture Protecting material	- PE/AL/PE Tape longtitude bonded - Extrude PE Sheath - Extrude modified polyamide jacket
Bedding	LSOH thermoplastic compound
Armour	Galvanized Steel wire comply with BS 1442
Outer Sheath	LSOH thermoplastic compound, colour is blue for I.S. cables, black otherwise.
Core Identification	Number Black / White for pairs. Number Black / White / Red for triples.

6.1.2 Signal Cables for Foundation Fieldbus

The foundation Fieldbus cable should be according to IEC 61158-1

Rating	300 V
Temperature	-40~70 °C (Mounting Temperature not under 5°C)
Material	outer jacket : PVC or PE Insulation : XLPE
Conductor	2x 0.8 mm2 (2/18 AWG) Stranded bare copper twisted pair with Armour (if required)
DC resistance	< 42.8 Ω/m
Rated current	13.6 A
Nominal impedance	88±8 Ω at 1 MHz.
Nominal capacitance	conductor to conductor 56.4±6.5 pF/m conductor to shield 91.8±9.8 pF/m
Nominal inductance	0.48 μH/m
Attenuation	<2.5dB/km at 38.4 kHz
Shield	Aluminum foil (100% coverage) 0.5 mm^2 (20 AWG), stranded tinned copper 0.8 mm^2 (18 AWG), stranded bare copper twisted pair
Bending Radii	>120 mm

6.1.3 Signal Cables for Fire and Gas Detection Service And Plant Communication

Cables for low level 4-20 mA signals to/from flame and gas detectors, mA level signals from smoke detectors, manual break-glass stations, fire protection service field transmitters, electronic level binary status signals for fire alarms, telephones, loudspeakers, visual warning lights including inter fire and gas panel signals and inter communication panel signals shall be of the type described in this section.

Cables shall be 300/500 V comply to

STANDARD APPLICABLE

BS 5308-1	Design Guideline
BS 6234	Specification for polyethylene insulation and sheath of electric cable
IEC 60332-1	Flame Retardant
IEC 60332-3C	Fire Retardant on Bunched Cables
BS1442	Specification for Galvanized mild steel wire for Armouring Cables
IEC 60754-1, 2	Halogen free properties
IEC 61034-1,2	Low smoke emission

Detailed specification shall be as below:

Conductors	Anneal Copper Wires according to Class 1 or 2 or 5 of BS 602281.0 or 1.5 mm^2.0.5 mm^2 cores may be used for telephones.
Fire barrier	Mica/glass tape
Insulation	XLPE in accordance with IEC 60502
Pairs	Twisted
Identification pairs	Black, white numbered
Assembly	Concentric Layers

Overall Screen	Aluminums / Polyester tape 0.024 mm in electrical contact with tinned annealed copper wires of a total section of 0.5 mm^2 polyester tape 0.023 mm
Bedding	LSOH compound
Armour	Galvanized Steel wire comply with BS 1442
Outer Sheath	LSOH compound, colour is blue for I.S. cables, black otherwise.
Core Identification	Number Black / White for pairs. Number Black / White / Red for triples.

6.1.4 Cables for Instrumentation Power Signals

Cables for instrumentation 24 V DC power signals for solenoid valves, control relays, etc. shall be as per Section 6.1.1 Core sizes shall be 2.5 mm^2 or 4.0 mm^2, as required to minimize voltage drop to less than 10 % of nominal applied voltage over long cable runs.

6.1.5 Cables for Fire and General Alarm Protection Service

Cables for fire and gas and general alarm system power signals for fire protection solenoid valves, control relays and strobe lamps, etc. shall be as per Section 6.1.1 Core sizes shall be 2.5 mm^2 or 4.0 mm^2, as required to minimize voltage drop to less than 10% of nominal applied voltage over long cable runs.

6.1.6 Thermocouple Cables

Thermocouple extension cables shall be flame retardant to IEC 60332 Part 3, Cat. A and shall generally be as follows:

STANDARD APPLICABLE

BS 5308-1	Design Guideline

BS1442	Specification for Galvanized mild steel wire for Armouring Cables
IEC 60332-1	Flame Retardant
IEC 60332-3C	Fire Retardant on Bunched Cables (if required)
IEC 60754-1, 2	Halogen free properties
IEC 61034-1,2	Low smoke emission

Thermocouple extension cables shall be flame retardant to IEC 60332 Part 3, Cat. A and shall generally be as follows:

Conductors	Solid alloy conductor
Insulation	XLPE
Pairs	Twisted
Identification pairs	Numbered pairs and colour code according to ANSI MC 96.1
Individual screen	Aluminium / Polyester tape 0.024 mm in electrical contact with tinned annealed copper wires of a total section of 0.5 mm^2 polyester tape 0.023 mm
Assembly	Concentric Layers
Overall Screen	Aluminium / Polyester tape 0.024 mm in electrical contact with tinned annealed copper wires of a total section of 0.5 mm^2 polyester tape 0.023 mm
Bedding	LSOH thermoplastic compound
Armour	Galvanized Steel wire comply with BS 1442
Outer Sheath	LSOH thermoplastic compound, colour is blue for I.S. cables, green otherwise.
Core Identification	Number Black / White for pairs. Number Black / White / Red for triples.

6.1.7 Computer and Data Transmission Cables

Cables for digital data transmission between computers / electronic systems for outdoor or hazardous area service shall be flame retardant to IEC 60332 Part 3, Cat. A, and fire resistant to IEC 60331. The data transmission cables shall have minimum armour and cable oversheath requirement as below:

Armour :	Steel Wire Armoured / Braid
Sheath :	LSOH thermoplastic compound

Electrical properties of computer and data transmission cables shall be determined by Contractor in detailed design phase.

6.1.8 Fiber Optic Cables

Fiber optic cables selection shall be considered according to the purpose of use and application.

Generally, fiber optic cables shall be widely used in multimode cable because of theirs economical price and required specification. In case of need in higher transmission rate and more distance than multi-mode, single mode cable can be applied.

Step index multimode was the first fiber design but is too slow for most uses, due to the dispersion caused by the different path lengths of the various modes. Step index fiber is rare - only Plastic Optical Fiber (POF) uses a step index design today.

Graded index multimode fiber uses variations in the composition of the glass in the core to compensate for the different path lengths of the modes. It offers hundreds of times more bandwidth than step index fiber - up to about 2 GHz.

Single mode fiber shrinks the core down so small that the light can only travel in one ray. This increases the bandwidth to almost infinity - but it's practically limited to about 100,000 GHz.

Fiber types and optical performances			
Core/cladding	Attenuation	Bandwidth	Application/Note
Multi-mode Graded-Index			
	@850 / 1300 nm	**@850 / 1300 nm**	
50 / 125 micron	3 / 1 dB/km	500 / 500 MHz-km	Laser-rated for GbE LANs
50 / 125 micron	3 / 1 dB/km	2000/ 500 MHz-km	Optimized for 850 nm VCSELs
62.5 / 125 micron	3 / 1 dB/km	160 / 500 MHz-km	Most common LAN fiber
Single Mode			
	@1310 / 1550 nm		
0-9 / 125 micron	0.4 / 0.25 dB/km	~100 TeraHz	Talco / CATV / long high speed LANs
Multi-mode Step-Index			
	@850 nm	**@850 nm**	
200 / 240 micron	4-6 dB/km	50 MHz-km	Slow LANs and Links
POF (Plastic Optical Fiber)			
	@850 nm	**@850 nm**	
1 mm.	~1 dB/km	~5 MHz-km	Short Links and Cars

Cable Description:

STANDARD APPLICABLE

IEC 60794-1	Optical Fiber Cables
IEC 60332-1	Flame Retardant
IEC 60332-3C	Fire Retardant on Bunched Cables (if required)
IEC 60754-1, 2	Halogen free properties
IEC 61034-1,2	Low smoke emission

1. **Outdoor cable**
   Loose-Tube cables are typically used for outside-plant installation in aerial, duct and direct buries.
   Armored loose-tube cables are preferably required if it's suitable with application.

2. **Indoor cable**
   Single-fiber tight-buffered cables are used as pigtails, patch cords and jumpers to terminate loose-tube cables directly into opto-electronic transmitters, receivers and other active and passive components.
   Multi-fiber tight-buffered cables are primarily used for alternative routing and handling flexibility and ease within buildings.

3. **Moisture Barrier**
   Fiber optic outdoor cables shall consist of water blocking material, water blocking ring, moisture barrier sheath or other method which is applicable in order to form moisture protection.

4. **Jacketing / Sheathing**
   Sheath shall be LSOH thermoplastic compound.

6.1.9 Grounding Cables

All Grounding cables shall be a single core cable and be as per Section 6.1.1 Core sizes shall be 2.5 mm^2 for grounding of instrumentation devices, which not grounded by instrument cable, otherwise ,such as for grounding of main equipments, system ground, etc., core sizes shall be in accordance with IEC-60364-5-54 earthing arrangement and protective.
The insulation color of grounding wire shall always be as followings.

Safety Ground:	green-yellow
Shield Ground:	solid green
DCS Ground :	dark blue
IS Ground :	blue-yellow

7. CABLE MARKING, DRUMMING AND PACKING

7.1 Cable Marking

The oversheath of each cable shall be marked to allow clear legibility of cable data as follows:

- Manufacturer's name and year of manufacture.
- Voltage grade.
- Cable type.
- Number of cores and core size.
- IEC/BS (if cable fully complies with the applicable standard).
- Length marking at every metre.

7.2 Cable Drum Marking

Each cable drum shall be marked with a permanently-attached stainless steel label showing the following information:

- Company's project name
- Contractor's purchase requisition number.
- Manufacturer's name.
- Manufacturer's job number.
- Manufacturer's works name where the cable has been manufactured.
- Drum size.
- Drum number.
- Cable type.
- Voltage grade.
- Number of cores and core size.
- Exact cable length on drum (m).
- Weight of cable (net weight in kg).
- Weight of cable drum (kg).
- Total weight (gross weight in kg).

7.3 Drumming And Packing

All drum cables shall be continuous without splices. Instrument cables shall be coiled on drums in detailed specified lengths.

Cable ends shall be sealed with heat-shrunk end cap immediately after testing to protect the cables from ingress of moisture.

Cables shall be shipped on non-returnable steel or wooden drums of robust construction and fully lagged with wooden battens or covered to avoid any damage to the cables during transportation, storage and handling. Packing life shall be a minimum of 6 months. The clearance from the perimeter of the drum flange to the outermost layer of cable shall be at least 50 mm or one cable diameter, whichever is larger.

8. QUALITY ASSURANCE

8.1 General

The Vendor shall operate a quality system satisfying the provisions of ISO 9001 or agreed equivalent standard, commensurate with the goods and services provided.

8.2 Inspections During Manufacturing

The Company reserves the right to carry out at least one inspection during manufacturing.

9. DOCUMENTATION

9.1 Documentation Required With Vendor's Bid

The following documents shall be supplied with the Vendor's bid:

- Manufacturers' technical brochures.
- Cable specification, description, technical data and applicable standards.
- Documentary evidence that type tests have been performed at the Manufacturers' works or at a recognized testing authority to very that all cable designs offered can perform to the design standards.
- Cross-sectional view of each cable type showing the material construction and dimensions.
- Manufacturers' standard quality assurance and quality control procedures.
- References for oil and gas, petrochemical and industrial projects.

END OF SECTION

SECTION II 0.6/1 KV ARMORED CABLE

1. SCOPE

This specification defines the minimum requirements for the design, manufacture, inspection, testing. packing and shipping of 0.6/1 kV armoured cables.

This specification covers 0.6/1kV copper conductor, cross-linked poly-ethylene (XLPE) insulated, PVC inner covering, galvanized steel wire armored and LSOH oversheathed power cables mainly in accordance with IEC 60502.

This insulation is recommended for operation at maximum rated conductor temperature 90 degree C.

The flame retardant class shall comply with IEC 60332-1 Part 1.

2. DEFINITIONS

Company	:	PTT (PTT Public Company Limited)
Contractor	:	The party that carries out all or part of the EPCC contract.
Purchaser	:	Company or Contractor as specified in the covering letter of the inquiry document.
Vendor	:	Manufacturer/Supplier/Vendor is the party that manufactures or supplies equipment and services to perform the duties specified by the Purchaser.

3. APPLICABLE CODES, STANDARDS AND REGULATIONS

The applicable sections, latest editions and supplements of the following codes, standards and regulations, unless modified herein, shall constitute minimum requirements and form part of this specification:

IEC 60228	Conductors of Insulated Cables.
IEC 60502	Extruded Solid Dielectric Insulated Power Cable for Rated Voltage from 1 KV up to 30 KV.

IEC 60332-1	Flame Retardant
IEC 60332-3C	Fire Retardant on Bunched Cables (If required)
BS1442	Specification for Galvanized mild steel wire for Armouring Cables
IEC 60754	Halogen free properties
IEC 61034	Low smoke emission

Any conflict between this specification and referenced documents shall be brought to the attention of the Company in writing for resolution. In general, the order of precedence is:

- Thai national laws, statutory and local authority regulations.
- This specification.
- Referenced codes and standards.

Compliance with this specification does not relieve the Contractor of the responsibility of supplying cables of proper design and construction and full suitability for all the specified operating conditions.

4. DESIGN DATA

4.1 Environmental Conditions

The electrical cables shall be suitable for use in the site environmental conditions as detailed in ‘Basis of Design’.

5. MATERIALS AND DESIGN

Materials shall be new and of high quality. Cables offered must be of current proven design. Prototype materials and designs are not acceptable.

6. TECHNICAL REQUIREMENTS

6.1 Conductor

The conductor shall be round, circular stranded conductor of plain annealed copper wires in accordance with IEC 60228.

6.2 Insulation

The insulation shall be of cross-linked polyethylene (XLPE).

The average thickness shall be not less than the value given in the attached table.

The minimum thickness at any point shall be not less than 90% of the specified value by more than 0.1 mm.

6.3 Core Identification

Each core shall be identified by the colored tape over the conductor and the colors shall be in accordance with followings.

2Core : Black, White

6.4 Cabling of Cores

The required number of cores shall be cabled with suitable fillers in round shape and a suitable tape shall be applied over the cabled cores.

6.5 Inner Covering

The inner covering shall be an extruded layer of black PVC compound.

6.6 Armour

The armor shall consist of single layer of galvanized steel round wire.

A suitable binder tape may be applied over it.

6.7 Over Sheath

The over sheath shall be an extruded layer of black LSOH thermoplastic compound, flame-retardant.
Additives for UV resistant, anti-rodent and anti-termite are a must.

7. CABLE MARKING, DRUMMING AND PACKING

7.1 Cable Marking

The over-sheath of each cable shall be marked to allow clear legibility of cable data as follows:

- Manufacturer’s name and year of manufacture.
- Voltage grade.
- Cable type.
- Number of cores and core size.
- IEC/BS (if cable fully complies with the applicable standard).
- Length marking at every metre.

7.2 Cable Drum Marking

Each cable drum shall be marked with a permanently-attached stainless steel label showing the following information:

- Company’s project name
- Contractor’s purchase requisition number.
- Manufacturer’s name.
- Manufacturer’s job number.
- Manufacturer’s works name where the cable has been manufactured.
- Drum size.
- Drum number.
- Cable type.
- Voltage grade.
- Number of cores and core size.
- Exact cable length on drum (m).
- Weight of cable (net weight in kg).
- Weight of cable drum (kg).
- Total weight (gross weight in kg).

For the medium voltage cables, an additional permanently-attached stainless steel label shall indicate the motor/panel tag numbers that the respective supply cables on the drum are assigned to.

7.3 Drumming and Packing

All drum cables shall be continuous without splices. Low voltage cables with size above 50 mm^2 and all medium voltage and high voltage cables shall be coiled on drums in detailed specified lengths.

Cable ends shall be sealed with heat-shrunk end cap immediately after testing to protect the cables from ingress of moisture.

Cables shall be shipped on non-returnable steel or wooden drums of robust construction and fully lagged with wooden battens or covered to avoid any damage to the cables during transportation, storage and handling. Packing life shall be a minimum of 6 months. The clearance from the perimeter of the drum flange to the outermost layer of cable shall be at least 50 mm or one cable diameter, whichever is larger.

8. QUALITY ASSURANCE

8.1 General

The Vendor shall operate a quality system satisfying the provisions of ISO 9001 or agreed equivalent standard, commensurate with the goods and services provided.

8.2 Inspections during Manufacturing

The Company reserves the right to carry out at least one inspection during manufacturing.

8.3 Factory Tests

The Company will witness factory tests when the electrical cables have been manufactured and are in “ready for dispatch” condition.

8.3.1 Factory Tests for Electrical Cables

All tests including but not limited to the following tests as per the relevant IEC/BS standards shall be performed on each cable. Test certificates shall be submitted to the Company.

8.3.1.1 Inspections

- Visual inspection for concentricity, dimension checks and cable marking, etc.

8.3.1.2 Routine Tests

- Spark tests on conductor insulation and oversheath.
- Conductor resistance measurements.
- Partial discharge tests (for medium voltage cables only).
- High voltage tests on completed cable (at 50 Hz for 5 minutes).
- Continuity tests for conductor and screen.

8.3.1.3 Special Tests

- Conductor examination by inspection and measurement for compliance to IEC 60228 (or BS 6360).
- Check on thickness of insulation, inner (separation) sheath, braid and armoring wires, sheath, etc.
- Voltage test on medium voltage cables (at 50 Hz for 4 hours).
- Hot set test for XLPE insulation and sheath.
- Fire resistance tests to IEC 60331 or BS 6387 type B.

8.3.1.4 Type Tests

- Electrical, for medium voltage cables as per Table 5 of IEC 60502.

9. DOCUMENTATION

9.1 Documentation Required With Vendor's Bid

The following documents shall be supplied with the Vendor's bid:

- Manufacturers' technical brochures.

- Cable specification, description, technical data and applicable standards.

- Documentary evidence that type tests have been performed at the Manufacturers' works or at a recognized testing authority to very that all cable designs offered can perform to the design standards.
- Cross-sectional view of each cable type showing the material construction and dimensions.
- Manufacturers' standard quality assurance and quality control procedures.
- References for oil and gas, petrochemical and industrial projects.

END OF SECTION

SECTION III 0.6/1 KV ARMORED CABLE WITH SHIELD

1. SCOPE

This specification defines the minimum requirements for the design, manufacture, inspection, testing. packing and shipping of 0.6 kV armoured cables.

This specification covers 600V PVC insulated, twisted, individual and common aluminum laminated polyester tape shielded, PVC separation sheathed, steel wire armoured, LSOH over-sheathed control.

This insulation is recommended for operation at maximum rated conductor temperature 70 degree C.

The flame retardant class shall comply with IEC 60332-1 Part 1.

2. DEFINITIONS

Company	:	PTT (PTT Public Company Limited)
Contractor	:	The party that carries out all or part of the EPCC contract.
Purchaser	:	Company or Contractor as specified in the covering letter of the inquiry document.
Vendor	:	Manufacturer/Supplier/Vendor is the party that manufactures or supplies equipment and services to perform the duties specified by the Purchaser.

3. APPLICABLE CODES, STANDARDS AND REGULATIONS

The applicable sections, latest editions and supplements of the following codes, standards and regulations, unless modified herein, shall constitute minimum requirements and form part of this specification:

IEC 60228	Conductors of Insulated Cables.
IEC 60502	Extruded Solid Dielectric Insulated Power Cable for Rated Voltage from 1 KV up to 30 KV.
IEC 60332-1	Flame Retardant

IEC 60332-3C	Fire Retardant on Bunched Cables (If required)
BS1442	Specification for Galvanized mild steel wire for Armouring Cables
IEC 60754	Halogen free properties
IEC 61034	Low smoke emission

Any conflict between this specification and referenced documents shall be brought to the attention of the Company in writing for resolution. In general, the order of precedence is:

- Thai national laws, statutory and local authority regulations.
- This specification.
- Referenced codes and standards.

Compliance with this specification does not relieve the Contractor of the responsibility of supplying cables of proper design and construction and full suitability for all the specified operating conditions.

4. DESIGN DATA

4.1 Environmental Conditions

The electrical cables shall be suitable for use in the site environmental conditions as detailed in 'Basis of Design'.

5. MATERIALS AND DESIGN

Materials shall be new and of high quality. Cables offered must be of current proven design. Prototype materials and designs are not acceptable.

6. TECHNICAL REQUIREMENTS

6.1 Conductor

The conductor shall be a plain annealed circular stranded copper conductors complying with IEC 60228.

6.2 Insulation

The insulation shall be extruded layer of PVC complying with international standard.

A suitable separator tape may be applied over the conductor.

6.3 Pair/Triad

Two core/Triad (Black and White, Red) shall be twisted together to form a pair (triad).

In case of 1pair, Triad, a suitable tape shall be applied helically over the cabled core with suitable fillers.

6.4 Individual Shield

An aluminum-laminated plastic tape of the thickness about 0.021㎜ shall be applied over the pair.

A tinned copper wire (0.5㎟, 7stranded) shall be inserted throughout the length, to contact with the aluminum side of this tape, for electrical grounding.

6.5 Assembly of Pair

The required number of shielded pair (triad) shall be cabled with fillers in round shape and a suitable tape shall be applied helically over the cabled pair (triad).

6.6 Common Shield

An aluminum-laminated plastic tape of the thickness about 0.05mm shall be applied over the assembled pair. A tinned copper wire (0.5㎟,7stranded) shall be inserted throughout the length, to contact with the aluminum side of this tape, for electrical grounding.

6.7 Identification

The pairs (Triads) shall be identified by printed white color numbers on the black insulation and black color numbers on the white (red) insulation and the intervals between adjacent numbers shall not exceed 30㎜..

6.8 Separation sheath

The separation sheath shall be an extruded layer of black PVC compound.

The minimum thickness at any point shall be not less than 80％ of the specified value by more than 0.2㎜..

6.9 Armour

The armour shall consist of single layer of galvanized steel wires.

A suitable binder tape may be applied over it.

6.10 Over Sheath

The over sheath shall be an extruded layer of black LSOH thermoplastic compound, flame-retardant.
Additives for UV resistant, anti-rodent and anti-termite are a must.
.

7. CABLE MARKING, DRUMMING AND PACKING

7.1 Cable Marking

The over-sheath of each cable shall be marked to allow clear legibility of cable data as follows:

- Manufacturer's name and year of manufacture.
- Voltage grade.
- Cable type.
- Number of cores and core size.
- IEC/BS (if cable fully complies with the applicable standard).
- Length marking at every metre.

7.2 Cable Drum Marking

Each cable drum shall be marked with a permanently-attached stainless steel label showing the following information:

- Company's project name
- Contractor's purchase requisition number.
- Manufacturer's name.

- Manufacturer's job number.
- Manufacturer's works name where the cable has been manufactured.
- Drum size.
- Drum number.
- Cable type.
- Voltage grade.
- Number of cores and core size.
- Exact cable length on drum (m).
- Weight of cable (net weight in kg).
- Weight of cable drum (kg).
- Total weight (gross weight in kg).

For the medium voltage cables, an additional permanently-attached stainless steel label shall indicate the motor/panel tag numbers that the respective supply cables on the drum are assigned to.

7.3 Drumming and Packing

All drum cables shall be continuous without splices. Low voltage cables with size above 50 mm^2 and all medium voltage and high voltage cables shall be coiled on drums in detailed specified lengths.

Cable ends shall be sealed with heat-shrunk end cap immediately after testing to protect the cables from ingress of moisture.

Cables shall be shipped on non-returnable steel or wooden drums of robust construction and fully lagged with wooden battens or covered to avoid any damage to the cables during transportation, storage and handling. Packing life shall be a minimum of 6 months. The clearance from the perimeter of the drum flange to the outermost layer of cable shall be at least 50 mm or one cable diameter, whichever is larger.

8. QUALITY ASSURANCE

8.1 General

The Vendor shall operate a quality system satisfying the provisions of ISO 9001 or agreed equivalent standard, commensurate with the goods and services provided.

8.2 Inspections during Manufacturing

The Company reserves the right to carry out at least one inspection during manufacturing.

8.3 Factory Tests

The Company will witness factory tests when the electrical cables have been manufactured and are in “ready for dispatch” condition.

8.3.1 Factory Tests for Electrical Cables

All tests including but not limited to the following tests as per the relevant IEC/BS standards shall be performed on each cable. Test certificates shall be submitted to the Company.

8.3.1.1 Inspections

- Visual inspection for concentricity, dimension checks and cable marking, etc.

8.3.1.2 Routine Tests

- Spark tests on conductor insulation and oversheath.
- Conductor resistance measurements.
- Partial discharge tests (for medium voltage cables only).
- High voltage tests on completed cable (at 50 Hz for 5 minutes).
- Continuity tests for conductor and screen.

8.3.1.3 Special Tests

- Conductor examination by inspection and measurement for compliance to IEC 60228 (or BS 6360).
- Check on thickness of insulation, inner (separation) sheath, braid and armoring wires, sheath, etc.
- Voltage test on medium voltage cables (at 50 Hz for 4 hours).
- Hot set test for XLPE insulation and sheath.
- Fire resistance tests to IEC 60331 or BS 6387 type B.

8.3.1.4 Type Tests

- Electrical, for medium voltage cables as per Table 5 of IEC 60502.

9. DOCUMENTATION

9.1 Documentation Required With Vendor's Bid

The following documents shall be supplied with the Vendor's bid:

- Manufacturers' technical brochures.
- Cable specification, description, technical data and applicable standards.
- Documentary evidence that type tests have been performed at the Manufacturers' works or at a recognized testing authority to very that all cable designs offered can perform to the design standards.
- Cross-sectional view of each cable type showing the material construction and dimensions.
- Manufacturers' standard quality assurance and quality control procedures.
- References for oil and gas, petrochemical and industrial projects.

END OF SECTION

SECTION IV 0.6 KV ARMORED CABLE

1. SCOPE

This specification defines the minimum requirements for the design, manufacture, inspection, testing. packing and shipping of 0.6 kV armoured cables.

This specification covers 600V PVC insulated, PVC inner covered, single wire armoured and LSOH over-sheathed control cables.

This insulation is recommended for operation at maximum continuous conductor temperature 70 degree C.

The flame retardant class shall comply with IEC 60332-1 Part 1.

2. DEFINITIONS

Company	:	PTT (PTT Public Company Limited)
Contractor	:	The party that carries out all or part of the EPCC contract.
Purchaser	:	Company or Contractor as specified in the covering letter of the inquiry document.
Vendor	:	Manufacturer/Supplier/Vendor is the party that manufactures or supplies equipment and services to perform the duties specified by the Purchaser.

3. APPLICABLE CODES, STANDARDS AND REGULATIONS

The applicable sections, latest editions and supplements of the following codes, standards and regulations, unless modified herein, shall constitute minimum requirements and form part of this specification:

IEC 60228	Conductors of Insulated Cables.
IEC 60502	Extruded Solid Dielectric Insulated Power Cable for Rated Voltage from 1 KV up to 30 KV.
IEC 60332-1	Flame Retardant

IEC 60332-3C	Fire Retardant on Bunched Cables (If required)
BS1442	Specification for Galvanized mild steel wire for Armouring Cables
IEC 60754	Halogen free properties
IEC 61034	Low smoke emission

Any conflict between this specification and referenced documents shall be brought to the attention of the Company in writing for resolution. In general, the order of precedence is:

- Thai national laws, statutory and local authority regulations.
- This specification.
- Referenced codes and standards.

Compliance with this specification does not relieve the Contractor of the responsibility of supplying cables of proper design and construction and full suitability for all the specified operating conditions.

4. DESIGN DATA

4.1 Environmental Conditions

The electrical cables shall be suitable for use in the site environmental conditions as detailed in 'Basis of Design'.

5. MATERIALS AND DESIGN

Materials shall be new and of high quality. Cables offered must be of current proven design. Prototype materials and designs are not acceptable.

6. TECHNICAL REQUIREMENTS

6.1 Conductor

The conductor shall be a plain annealed circular stranded copper conductors complying with IEC 60228.

6.2 Insulation

The insulation shall be extruded layer of PVC complying with international standard.

A suitable separator tape may be applied over the conductor.

6.3 Core identification

The individual cores shall be identified by the following.

2 Cores: Red, Black
3 Cores and above: to be identified by white numbers on the black insulations

6.4 Assembly

The required number of core shall be assembled together with, suitable filler if necessary; to form the compact circular form and a suitable binder tape may be applied helically over the cabled cores.

6.5 Inner covering

The inner covering shall be an extruded layer of black PVC compound.

6.6 Armour

The armour shall consist of single layer of galvanized steel wires.

A suitable binder tape may be applied over it.

6.7 Over Sheath

The over sheath shall be an extruded layer of black LSOH thermoplastic compound, flame-retardant.
Additives for UV resistant, anti-rodent and anti-termite are a must.
.

7. CABLE MARKING, DRUMMING AND PACKING

7.1 Cable Marking

The over-sheath of each cable shall be marked to allow clear legibility of cable data as follows:

- Manufacturer's name and year of manufacture.
- Voltage grade.
- Cable type.
- Number of cores and core size.
- IEC/BS (if cable fully complies with the applicable standard).
- Length marking at every metre.

7.2 Cable Drum Marking

Each cable drum shall be marked with a permanently-attached stainless steel label showing the following information:

- Company's project name
- Contractor's purchase requisition number.
- Manufacturer's name.
- Manufacturer's job number.
- Manufacturer's works name where the cable has been manufactured.
- Drum size.
- Drum number.
- Cable type.
- Voltage grade.
- Number of cores and core size.
- Exact cable length on drum (m).
- Weight of cable (net weight in kg).
- Weight of cable drum (kg).
- Total weight (gross weight in kg).

For the medium voltage cables, an additional permanently-attached stainless steel label shall indicate the motor/panel tag numbers that the respective supply cables on the drum are assigned to.

7.3 Drumming and Packing

All drum cables shall be continuous without splices. Low voltage cables with size above 50 mm^2 and all medium voltage and high voltage cables shall be coiled on drums in detailed specified lengths.

Cable ends shall be sealed with heat-shrunk end cap immediately after testing to protect the cables from ingress of moisture.

Cables shall be shipped on non-returnable steel or wooden drums of robust construction and fully lagged with wooden battens or covered to avoid any damage to the cables during transportation, storage and handling. Packing life shall be a minimum of 6 months. The clearance from the perimeter of the drum flange to the outermost layer of cable shall be at least 50 mm or one cable diameter, whichever is larger.

8. QUALITY ASSURANCE

8.1 General

The Vendor shall operate a quality system satisfying the provisions of ISO 9001 or agreed equivalent standard, commensurate with the goods and services provided.

8.2 Inspections during Manufacturing

The Company reserves the right to carry out at least one inspection during manufacturing.

8.3 Factory Tests

The Company will witness factory tests when the electrical cables have been manufactured and are in “ready for dispatch” condition.

8.3.1 Factory Tests for Electrical Cables

All tests including but not limited to the following tests as per the relevant IEC/BS standards shall be performed on each cable. Test certificates shall be submitted to the Company.

8.3.1.1 Inspections

- Visual inspection for concentricity, dimension checks and cable marking, etc.

8.3.1.2 Routine Tests

- Spark tests on conductor insulation and oversheath.
- Conductor resistance measurements.
- Partial discharge tests (for medium voltage cables only).
- High voltage tests on completed cable (at 50 Hz for 5 minutes).

- Continuity tests for conductor and screen.

8.3.1.3 Special Tests

- Conductor examination by inspection and measurement for compliance to IEC 60228 (or BS 6360).
- Check on thickness of insulation, inner (separation) sheath, braid and armoring wires, sheath, etc.
- Voltage test on medium voltage cables (at 50 Hz for 4 hours).
- Hot set test for XLPE insulation and sheath.
- Fire resistance tests to IEC 60331 or BS 6387 type B.

8.3.1.4 Type Tests

- Electrical, for medium voltage cables as per Table 5 of IEC 60502.

9. DOCUMENTATION

9.1 Documentation Required With Vendor's Bid

The following documents shall be supplied with the Vendor's bid:

- Manufacturers' technical brochures.

- Cable specification, description, technical data and applicable standards.

- Documentary evidence that type tests have been performed at the Manufacturers' works or at a recognized testing authority to very that all cable designs offered can perform to the design standards.

- Cross-sectional view of each cable type showing the material construction and dimensions.

- Manufacturers' standard quality assurance and quality control procedures.

- References for oil and gas, petrochemical and industrial projects.

END OF SECTION

Attachment

Thickness of Insulation (for Item 6.2)

Conductor size (Sq.mm.)	Thickness of Insulation (mm.)
2.5	0.7
4	0.7
6	0.7
10	0.7
16	0.7
25	0.9
35	0.9
50	1.0
70	1.1
95	1.1
120	1.2
150	1.4
185	1.6
240	1.7
300	1.8
400	2.0

PTT PUBLIC COMPANY LIMITED

GAS SEPARATION PLANT RAYONG

SPECIFICATION FOR CIVIL WORK

ES-40.01

REV. 03

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1.0 GENERAL

This standard defines the mandatory requirements for material and workmanship to be attained in the construction of Civil Works.

1.1 The defined terms as used in this Engineering Standard are set out in the Conditions of Contracts.

2.0 DEFINITIONS

For the purpose of this standard the definitions as defined in Section I of the PROJECT SPECIFICATION apply.

3.0 SCOPE

3.1 CONTRACTOR shall supply all materials, mechanical plant, supervision and labour necessary to construct civil works as defined on the drawings and in accordance with the standards and specification. All material and workmanship shall comply with this Standard and related codes and standards referred to within this Standard.

3.2 CONTRACTOR shall take note that some of the Civil Works for This Project shall take place within/close to EXISTING FACILITIES.

4.0 EARTHWORK

4.1 This section covers the requirements governing general earthwork, preparation for foundations, access roadways and paving subgrades.

CONTRACTOR shall provide the services of a Registered Thai (Geotechnical) Engineer to observe, test and evaluate all work operations. The report shall be Certified by an engineer according to Thai Laws.

CONTRACTOR shall satisfy himself as to the SITE conditions that exist and shall assess, the conditions that will exist at commencement of work.

CONTRACTOR shall also satisfy himself as to the nature of the work to be carried out including the existing conditions for excavations and any difficulties to be anticipated in dealing with dewatering excavations, excavated materials, floods, slips and subsidence arising out of the work.

Unsatisfactory ground conditions shall be reported in writing and any remedial work to be agreed by PTT/CONSULTANT before starting work.

Material and workmanship for earthworks shall be in accordance with the requirements of ASTM D1140, 1556, 1557, 1751, 4253 and 4254.

4.2 Reference standards

The following reference standards form part of this Engineering Standard:

4.2.1 American Society for Testing and Materials

ASTM C 117	Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 422	Standard Test Method for Particle-Size Analysis of Soils
ASTM D 698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-Ibf/ft3 600 kNm/m3)
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-Ibf/ft3 (2,700 kNm/m3))
ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2216	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D 4318	Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASSHTO :	
ASSHTO T 27	Sieve Analysis of Fine and Coarse Aggregate
ASSHTO T 99	Standard method of test for moisture-density relations of soils using a 2.5-kg (5.5 Ib) hammer and a 305-mm (12-in) drop
ASSHTO T 147	Standard method of field determination of density of soil in place
ASSHTO T 180	Standard method of test for moisture-density relations of soils using a 4.54-kg (10-Ib) hammer and a 457-mm (18-in) drop

4.2.2 Steel Structures Painting Council

SSPC Manual, Volume II Systems and Engineering Standards:

SSPC-SP 1 - Solvent Cleaning

SSPC-SP11 - Power-tool cleaning to bare metal.

4.2.3 NACE International

Recommended Practices:

RP 0274-93	High voltage electrical inspection of pipeline coatings prior to installation.
RP 0287-95	Field Measurement of Surface Profile of Abrasive Blast-cleaned steel surfaces using a Replica Tape.

4.2.4 ISO Standards

ISO 8501:	Preparation of steel substrates before application of paints and related products.

4.2.5 Project Engineering Standards

ES-40.01.04	Specification for SITE Preparation.
ES-40.12	Specification for road and paving.
ES-92.06	Painting

4.3 Agreement of Existing Levels and Outlines

CONTRACTOR shall agree existing ground levels (original surface) and dimensions with PTT/CONSULTANT before earthworks are commenced. All details of the SITE Survey and Benchmarking information shall be recorded by CONTRACTOR, agreed with PTT/CONSULTANT and copies submitted to him for attention.

4.4 Drainage

Before any extensive excavation and grading is undertaken, temporary culverts, drain lines and ditches shall be installed to effectively drainage of the SITE.

4.5 Excavation

4.5.1 Material to be excavated shall be classified and measured in its original position.

4.5.2 Excavation shall include the removal and transportation of all excavated materials whether wet or dry, from the point of excavation to storage within the SITE boundaries for final use as backfill material, or disposal to a tip outside the plant approval by PTT/CONSULTANT. The Transportation vehicle must have suitable cover to prevent falling of debris.

4.5.3 Artificial hard material shall mean any material such as existing mass or reinforced concrete requiring the use of blasting or approved pneumatic tools for its removal but excluding individual masses less than $0.2m^3$.

4.5.4 Rock shall mean any hard natural or artificial material requiring the use of blasting or approved pneumatic tools for its removal but excluding individual masses less than $0.2m^3$.

4.5.5 Measurement of Rock

If during the course of excavation, CONTRACTOR encounters what in his opinion is rock, he shall notify PTT/CONSULTANT immediately so that an examination is carried out. Should PTT/CONSULTANT agree that the material is rock as defined above, all necessary levels and dimensions shall be recorded and agreed before its removal is started. CONTRACTOR shall also agree the bulking factor with PTT/CONSULTANT.

4.5.6 Foundation excavation shall include:

a) All excavation and backfill required for all foundations to the specified lines, grade and dimensions.

b) Furnishing and installing sheet pilling and retaining structure to ensure stability of the excavation.

c) If soft or unstable materials are encountered near the bottom of a foundation excavation, CONTRACTOR shall submit suitable construction method immediately to PTT/CONSULTANT for review and comment.

4.5.7 All open excavations within the SITE and EXISTING FACILITIES shall be provided with temporary covers and safety fences with warning sign.

4.5.8 All general and local excavations shall be kept free of water at all times until completion of backfilling.

CONTRACTOR shall make provisions for the pumping out the water from the temporary drains, cuts and sumps as may be necessary for this purpose to PTT/CONSULTANT. All such cuts and sumps shall be filled in with concrete or other suitable filling as review and comment by PTT/CONSULTANT upon completion of the works.

Water pumped from excavations shall be pumped in a controlled manner without causing damage, or into an adjacent permanent drainage system. Adequate precautions shall be taken to ensure that existing drainage systems are protected from blockage by the ingress of materials and contamination.

4.5.9 Excavation of at least the final 150mm above formation level shall not be permitted until completed preparing for concrete blinding immediately and on raining condition. Care shall be taken when trimming formations to prevent any disturbance to the bearing strait.

4.5.10 Excavated material suitable for filling or other purposes shall not be removed from the SITE without the agreement of PTT/CONSULTANT.

4.5.11 Any unstable, deleterious or otherwise unsuitable material encountered at formation level shall be removed and excavations backfilled with concrete or other material.

4.5.12 In the event of any over-excavation in either local or general excavations such excavation shall be filled with other selected material witness or CONTRACTOR shall submit suitable construction method immediately to PTT/CONSULTANT for review and comment.

4.6 <u>Definitions of Levels</u>

4.6.1 Existing ground levels are defined as those existing on the SITE at the beginning of the contract.

4.6.2 Formation levels are defined as the surface level of the ground in individual foundation areas after completion of excavation and filling.

4.7 <u>Existing Underground Services</u>

Drawings showing existing underground services shall be verified by CONTRACTOR before commencing excavation work. CONTRACTOR shall be responsible for making investigations by hand digging or water jet method if depth of excavation over 1.50 m to expose any existing underground service.

Where existing underground services are known to exist, CONTRACTOR shall take all necessary steps to prevent damage to these services by approved methods of working including hand digging around, protection of and diversion of services.

4.8 Fill, Backfill and Compaction

Soil embankment permit is required. Contractor is responsible to communicate with sub district of administrative organization or concerned local department to get an approval on this permit.
Soil mechanics test report shall be submitted to PTT for approval. Report shall cover the following test as minimum:

a) Sieve Analysis

b) Compaction Test

c) CBR Test

d) Atterberg's Limits Test

4.8.1 Fill Materials

Materials for land fill or back fill shall be either excavated or imported material both subject to review and approve by PTT/CONSULTANT.

Approved imported material shall be durable inert graded granular material, such as graded limestone or other hard durable rock, or crushed graded laterite or sand, where excavated original ground material from below the granular fill is found to be unsuitable soft silty or organic clay, it shall be removed from the site and disposed of at an approved location.

It should be noted that stockpiled material may deteriorate and require to be reclassified later on. Acceptable fill material shall be defined as the following:

a) Imported crushed limestone, or laterite, or rock graded as follows:

Sieve	Percentage by Mass Passing

75 mm	100
40 mm	85 – 100
10 mm	45 – 100
5 mm	58 – 86
0.6 mm	8 – 45
0.075 mm	0 – 10

b) Imported sand

Sieve Size	Percentage by Mass Passing
10 mm	100
5 mm	90 - 100
2 mm	70 - 90
0.6 mm	22 - 50
0.2 mm	0 - 15
0.075mm	0 - 5

c) Excavated laterite fill - meeting the following requirements:

Uniformity coefficient of 10 or less, or containing 80% or more materials in the particle size 0.06mm - 0.002mm.

All material for road base course shall be crushed limestone to AASHTO grading requirements.

All fill material shall be free of rubbish vegetation, hydro-carbons, and acidic sulphates. The maximum acceptable soluble sulphate content shall not exceed 0.5% by mass.

4.8.2 Fill Placement

Proposals shall be submitted regarding the materials, their source, and the plant for spreading the compact filling and backfilling. Sample loads of the proposed imported fill materials shall be delivered to the site for inspection, testing and compaction trials. Fill material shall not be placed below water unless specified or authorised.

CONTRACTOR shall use the proposed methods and plant to meet all the specified requirements regarding compaction can be achieved. All necessary compaction tests shall be carried out during these trials.

Placement of fill shall be as follows:

a) All fill shall be placed in 200 mm maximum thickness loose lifts, except in small fill areas where maximum loose thickness shall not exceed 150 mm.

b) Fill shall not be placed against concrete retaining wall until the concrete strength has attained sufficient strength to support the load.

c) Sufficient fill shall be placed to allow for settlement, where a lesser degree of compaction is required, to avoid damage to buried piping or structures.

4.8.3 Backfill

Two classifications of backfill apply to pipe trenches, as follows:

a) Initial backfill, which includes the placing of suitable soil, free of lumps, stones, or foreign materials, in uniform compacted layers 100 mm thick until a 300mm cover is obtained over the top of the pipe.

b) Final backfill, which includes the placing of fill in uniform compacted layers to completely fill the excavation.

4.8.4 Compaction & Testing

Materials used as fill in embankments and elsewhere shall be compacted as soon as practicable after deposition. Compaction shall be undertaken in accordance with the minimum requirements of section 9.0, using approved plant.

Variations from the methods given in section 9.0, or in the use of plant not included therein, will be permitted only if the site trials demonstrate that the required degree of compaction can be achieved by the alternative method.

Earthmoving plant shall not be accepted as compaction.

In small fill areas, including backfilling in narrow widths to foundations pits and trenches for services, layers shall not exceed 150mm loose depth and shall be mechanically compacted.

Each layer in rockfill embankments shall be compacted by at least 12 passes of a heavy vibratory steel-wheeled rollers with a static mass per metre width of roll of at least 1,800 kg or a grid roller with a mass per metre width of roll of at least 8,000 kg or other approved plant.

The extent of compaction shall be limited by the type of fill (or backfill) and service, as follows:

a) Cohesive structural fill shall be compacted to 95% maximum dry density as per ASTM D1557.

b) Cohesionless structural fill shall be compacted to 95% relative density per ASTM D4253 & D4254 except that gravel and other large materials not adaptable to relative density tests shall be well compacted as approved.

c) Lesser degrees of applied compaction will be permitted only where the specified compaction density would be injurious to the buried structure.

Dry density testing to determine the degree of compaction shall be carried out in accordance with ASTM D1557.

The average frequency of the tests shall be one for each 100 square metre (m^2) in each layer of general bulk filling.

Additional dry density testing may be ordered on material, which is considered to have been inadequately compacted. If the test results show the state of compaction to be inadequate, the compaction work shall be carry out as necessary to achieve a satisfactory state of compaction.

If the test results show that the required state of compaction is consistently not being achieved. Further field trails should be carried out to establish an acceptable method of compaction.

4.8.5 Programming of Filling Operations

Filling operations shall be programmed so as to ensure that the specified compaction is attained throughout and that reasonable time is allowed for such tests as may be required.

4.9 Grading

Rough grading shall be carried to within a vertical tolerance of 60 mm of final lines, grades and slopes.

Final grades shall be carried out to the lines, grades, and slopes shown on the drawings, within a tolerance of 30 mm.

4.10 Additional Requirements for Roadway Subgrade

All materials, testing and construction work shall be carried out in accordance with, but not limited to standards in section 4.2

Earth sub-grade for roads shall include common excavation or fill and rough grading of roadways and embankments with their attendant shoulders and ditch.

The in-situ sub-grade shall be compacted by rolling and any soft material removed prior to placement of fill sub-base or base course materials.
Fill, backfill and compaction of the sub-grade, sub-base and base course shall be in accordance to section 4.8 of this standard.

The average frequency of the tests shall be one for each 50 metre run of the road surface.

Compacted granular fill shall be sealed by sprayed bitumen or similar material, within 24 hours of compaction.

5.0 CONCRETE WORKS

5.1 Scope

This section covers the mandatory requirements governing concrete construction.

5.2 References

All concrete materials, testing and construction work shall be carried out in accordance with, but not limited to following standards:

5.2.1 ACI Standards

224	Control of Cracking in Concrete Structures
301	Specification for Structural Concrete for Buildings
302	Guide for Concrete Floor and Slab Construction
304	Guide for Measuring, Mixing, Transporting and Placing Concrete
305	Hot Weather Concreting
308	Standard Practice for Curing of Concrete
318	Building Code Requirements for Reinforced Concrete
350R	Environmental Engineering Concrete Structure

5.2.2 Thai Standards

TIS 20:2543	Steel Bar for Reinforced Concrete, Round Bar
TIS 24:2548	Steel Bar for Reinforced Concrete, Deformed Bar
TIS 213:2552	Standard for ready-mixed concrete

5.2.3 ASTM Standards

C 31	Practice for Making and Curing Concrete Test Specimens in the field
C 33	Specification for Concrete Aggregates
C 39	Test Method for Compressive Strength of Cylindrical Concrete Specimens
C 42	Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C 94	Specification for Ready Mixed Concrete
C 109	Compressive Strength of Hydraulic Cement Mortars
C 143	Test Method for Slump of Hydraulic Cement Concrete
C 150	Specification for Portland Cement
C 171	Specification for Sheet Materials for Curing Concrete
C 172	Practice for Sampling Freshly Mixed Concrete
C 173	Test Method for Air Content of fresh Mixed Concrete by the Volumetric Method
C 192	Practice for Making and Curing Concrete Test Specimens in the Laboratory
C 260	Specification for Air Entraining Admixtures for Concrete
C 289	Test Method for Potential Reactivity of Aggregate (Chemical Method)
C 494	Specification for Chemical Admixtures for concrete
C1202	Standard test method for electrical indication of concrete ability to resist chloride ion penetration

5.2.4 AASHTO Standards

T26	Quality of Water to be used in Concrete

5.2.5 Engineering Standards

ES-40.09	Design of Concrete Foundation, Structure and Paving
ES-40.11	Design of Machine Foundations

5.3 Materials

5.3.1 General

All materials shall conform to the appropriate Standards. CONTRACTOR shall ensure that certificates are available for all materials including proprietary materials.

5.3.2 Chlorides

Maximum limit for chloride ion content of aggregates for all concrete mixes shall not exceed 0.03 expressed as percentage by mass of combined aggregates.
Maximum limit for chloride ion content of concrete shall be 0.2 expressed as percentage by mass of cement.

5.3.3 Sulphates

The total water soluble sulphate content of the concrete mix shall not exceed 4% SO_3 by weight of the cement in the mix. The sulphate content, expressed as SO_3 shall be calculated from the sulphate derived from the cement, any other cementitious material, the aggregate, any admixtures and any other source.

5.3.4 Alkali-Aggregate Reaction

Maximum alkali content of the concrete mix shall not exceed 3kg/m^3. For procedures for limiting and testing for alkali content refer to ASTM C289 and ASTM C150.

5.3.5 Cement

Unless otherwise specified, the cement shall be Ordinary Portland Cement, which conforms to ASTM C150 with Tricalcium Aluminate (C_3A) content not exceeding 12%. Cement shall be the same brand, manufactured at the same mill.

Manufacturer's certificates to the effect that cement has been tested and found to comply with the requirements of the appropriate American Standard and the above additional requirement shall be submitted, prior to the dispatch of each consignment from the manufacturers works.

The date, quantity of cement and the number of relevant delivery note shall also be stated.

Cement may be rejected as a result of further tests thereon which may be conducted notwithstanding the above mentioned manufacturer's certificate.

After delivery of the consignment, PTT/CONSULTANT shall have access to the cement store and samples may be taken for further tests to be carried out.

From the results of these tests, PTT/CONSULTANT may reject any consignment or part consignment, which does not comply with the relevant Standards.

5.3.6 Aggregate

The fine aggregates shall consist of natural sand or crushed stone and the coarse aggregates of natural gravel or crushed stone, all obtained from sources. Aggregates shall be hard, clean and free from any substance likely to reduce the strength and durability of the concrete. The clay, silt and fine dust content, the organic impurities and the aggregate crushing value shall be within the limits specified in ASTM C33. The grading of fine and coarse aggregate shall be in accordance with ASTM C33.

5.3.7 Sampling of Aggregates

Sampling and testing of aggregates shall be carried to in accordance with ASTM C33. If adequate laboratory facilities do not exist on SITE samples shall be taken and sent to an approved testing laboratory. Samples of 0.015 m and 0.03 m of fine and coarse aggregate respectively shall be sent in suitable air-tight containers.

The use of any aggregates that do not meet the requirements of the relevant Standards will not be permitted.

5.3.8 Water

Water used for mixing and curing of concrete shall comply with AASHTO T26.

5.3.9 Admixtures

Admixtures shall be used only with the written approval of PTT/CONSULTANT, and shall comply with ASTM C494.

All admixtures used to modify one or more characteristics of concrete shall be accompanied by a certificate from an approved institute, stating:

- exact range and method of application

- physical and chemical composition
- positive and negative side effects
- a recommendation of the maximum allowable quantities (as a percentage of the mass of the cement) to achieve the particular requirement
- proportioning and mixing

Admixtures shall contain no chlorides. If retarder and/or plasticizer are required only a dual-purpose additive shall be used.

Plasticizers, where approved, shall be used strictly in accordance with the manufacturer's instructions, and shall comply with ASTM C494.

Air entraining admixtures, for pavement concrete exposed to weather, shall comply with the requirements of ACI 318 & ASTM C260. Where admixtures have not been used strictly in accordance with the manufacturer's instruction, or where admixtures are shown to have adversely affected the hardened concrete, the affected work shall be treated in accordance with Clause 5.5.10 of this Standard.

5.3.10 Concrete

All concrete used shall be ready mixed in accordance with ACI 301, and TIS 213:2552 which produced from a supplier in close proximity to the SITE.

Special attention shall be paid to the curing of fresh concrete, the temperature of the mix constituents and formwork, water/cement ratio and the procedure of placing/compaction of concrete due to the hot weather which is experienced at the SITE.

The requirements of ACI 301, 304, 305 and 318 shall be adhered to for all concreting works. Concrete for all parts of the work shall be homogenous and, when hardened, shall have the required strength, resistance to deterioration, durability, resistance to abrasion, water tightness and appearance. Fluid tight concrete will have a maximum permitted width of crack less than 0.2mm.

Concrete grades shall be as denoted on the drawings and listed in **Table 1** below.

TABLE 1

READY MIX CONCRETE SELECTION CRITERIA

CONCRETE	APPLICATION	W/C	MAXIMUM	COMPRESSIVE

CLASS		RATIO	AGGREGATE SIZE(MM)	CYLINDER STRENGTH (KG/CM^2)	
				7 Day	28 Day
C35/40	Foundations, Retaining Wall, Post Tension Structures And Roads	0.4	25	315	350
C28/32	Beams, Columns, Slabs and Concrete Toppings	0.45	20	252	280
C24/28	Paving, Gutter, Manhole	0.5	20	216	240
C15/18	Lean concrete and Mass concrete	0.7	20	135	150

5.3.11 Reinforcement

Reinforcement shall be either:

a) Grade SR 24, plain round bars specified characteristic strength of 235 N/mm^2 in accordance with TIS 20:2543 - defined by letter R on schedule.

b) Grade SD 40, deformed hot rolled or cold worked reinforcement with characteristic strength of 400 N/mm^2 in accordance with TIS 24:2527 - defined by letter D on schedule. Grade SD 40 reinforcement shall be used for all structural concrete, links and stirrups unless noted otherwise on drawings.

c) Welded wire fabric in accordance with TIS 737:2549. This type of reinforcement shall be used for all concrete road and paving unless noted otherwise on drawings.

5.4 Handling and storage of Materials

5.4.1 Cement

Cement in sacks or bags shall be stored in waterproof, ventilated sheds, and the floors of the sheds shall be kept clear of the ground or otherwise protected from dampness. The cement shall be stored in such a way that the oldest deliveries are used first. Bagged cement shall not be stored higher than 10 bags. Re-bagged cement shall not be used.

If bulk cement is used, it shall be stored in approved containers. Cement bags containing lumps that cannot be broken by a light touch of the fingers shall not be used. Cement shall not be kept on SITE longer than 3 months.

5.4.2 Aggregates

CONTRACTOR shall ensure that adequate supplies of the aggregate are available prior to commencing work.

Each type of aggregate shall be separately transported and stored, and shall not be contaminated with any other type of aggregate or any other material. Where two types of aggregate are stored next to each other, they shall be separated by a wall or plate. The floor of storage areas shall be of concrete or other approved material having sufficient slope to ensure drainage of surplus water. Regular cleaning of aggregate bins shall be carried out to remove accumulated dust. Wet aggregate shall be kept on SITE for at least 24 hours to ensure adequate drainage before being used.

5.4.3 Reinforcement bar

Reinforcement bar shall be stacked on packing so that it is well clear of the ground and fully cover by all mean. Any reinforcement bar so affected shall be removed from the site. Reinforcement bar shall be stacked separately by grade and diameter and each stack shall be clearly labeled as to content. When reinforcement bar is to be cut and bent on SITE, it shall be delivered in straight lengths. Reinforcement bar which has been bent to facilitate transportation in short trucks will not be permitted. Mill Certificate with TIS Standard for reinforcement bar shall be in place for random material receiving inspection-complied with inspection and test plan.

5.4.4 Other Materials

All other materials shall be stored in an approved manner and standard practices as to protect them from defect, deterioration and contamination from whatever source.

5.4.5 Rejected Materials

All materials which are unidentified, or do not comply with this Standard shall be removed from the SITE immediately.

5.5 <u>Concrete Workmanship</u>

5.5.1 General

All workmanship and placement of concrete shall comply with the requirements of ACI standards 301, 318 and 305.

All concrete foundations and piers shall be cast within formwork shuttering.

All reinforcement shall be bent in accordance with the ACI Standard Code.

5.5.2 Measurement of Materials

Fine and coarse aggregates, cement and water shall be measured by weight, by means of an approved batching machine complying with ASTM C33.

Due allowance shall be made of the weight of the water carried by the aggregates in the stock pile before use. Aggregates for each batch shall be measured to within 2% accuracy by weight.

The mixing water shall be measured to within 1% accuracy by volume or by weight. Admixtures may be measured by volume to within 3% accuracy.

If the cement is supplied in bags, the batches for the various qualities of concrete shall be proportioned in such a manner as to avoid the necessity of using part bags in any batch. If the cement is stored in bulk, the measuring device shall be approved by PTT/CONSULTANT before use.

5.5.3 Workability, Slump and Mixing

Concrete shall be of such consistency that it can be readily worked into the corners and angles of the formwork and around reinforcement without segregation of the materials.

Workability shall be measured by the slump of concrete at time of placing.

Amount of water added to each batch of concrete shall be strictly controlled to yield agreed slump values. The degree of workability shall be compatible with the type of construction.

Specimens shall be made and cured in accordance with ASTM C192 and tested in accordance with ASTM C39. A curve representing the relation between the water content and the average 28 day compressive strength for the proposed cement content, or earlier strength at which the concrete is to receive its full working load, shall be established for a range of values including the compressive strength called for on the drawings. The curve shall be established by at least three (3) points, each point representing average values from at least four (4) test specimens.

The maximum allowable water content for concrete shall be determined from this curve and shall correspond to a strength 25 per cent greater than indicated herein or on the drawings. No substitutions shall be made in the materials used in the work without additional tests in accordance herewith to show that the quality of the concrete is satisfactory. In the field, consistency shall be determined by slump tests in accordance with ASTM

C143. The slump shall, in all cases, be as low as possible, and shall fall within the values given below:

Type of Construction	Slump, in mm Max.	*Min.
Roads and Pavings	100	50
Concrete Topping	150	100
Columns and Walls	150	100
Foundations, Beams and Slabs	125	75
Lean and Mass concrete	100	50
Concrete Pumps	150	100
Bored Pile		>150
High density reinforcement structure		>150

*May be increased by 25mm for methods of consolidation other than vibration.

Workability shall be measured whenever a sample for strength is taken. If the limits of workability are exceeded, actions which include, but are not necessarily limited to, increased sampling rates for workability, insistence of more stringent control of batching and mixing or rejection of the concrete shall be taken. The cost of such actions shall be borne by CONTRACTOR.

Concrete shall be mixed in a properly maintained batch mixer complying to ASTM C94. Mixing shall continue until there is a uniform distribution of colour and consistency of the materials, but for each batch of concrete the mixing shall continue for at least 2 minutes after all the materials are in the mixer. The mixer shall be operated according to the manufacturer's instructions and the entire content of the drum shall be discharged before recharging.

Hand mixing will be subject to the review and comment of PTT/CONSULTANT and may be used only in exceptional circumstances for non-structural mass concrete work. Where this is permitted the materials for each batch shall be gauged and mixed on a clean grout-tight platform and long pronged rakes shall be used in addition to shovels. The amount of cement used shall be 10% more than that as specified for machine mixing.

Cement and sand shall be first mixed together and turned over once in a dry state. They shall then be passed through a sieve of 20mm mesh on to the coarse aggregate, spread out evenly on the platform and the whole mass shall be turned over twice in a dry condition and three times after the necessary amount of water has been carefully added through a fine rose. Colour consistency and other provisions shall apply as for machine mixing.

5.5.4 Samples and Tests

5.5.4.1 Testing Plan

Certification that concrete mix is proportioned for strength specified per Table 1 shall be taken.

A quality plan shall be submitted at least two weeks before the start of testing, indicating the tests to be carried out on the individual materials and concrete composition and the frequency with which these tests shall be taken, as well as the required test results.

Test certificates for cement, aggregate, water and reinforcement are required to be provided prior to the start of work.

Cylinder tests shall be carried out by an independent laboratory.

5.5.4.2 Manufacture of Concrete Specimen

All Sampling shall be made in accordance with ASTM C172/C172M, ASTM D3665 and CSA A23.2-1C, cured in accordance with ASTM C31/C31M and tested in accordance with ASTM C39/C39M or ASTM C873/C, 873M-10a.

Sampling shall be clearly marked for identification purposes and a register of cylinders taken shall be kept indicating the date and type and position of concrete sampled for each set of cylinders. Reports of all cylinders test results shall be supplied to PTT/CONSULTANT within 24 hours of being carried out.

Fabrication of test cylinders and transportation to the laboratory shall be the responsibility of CONTRACTOR.

The initial rate of sampling for testing shall be at least once each day for a given class placed nor less than once for each 50 cubic metres of each class placed each day, and in accordance with **Table 2** below.

TABLE 2
RATE OF SAMPLING

TYPE OF STRUCTURE	SAMPLE TO REPRESENT A VOLUME OF m^3
Retaining Walls, Column.	10
Foundations, Beams, Slabs, Toppings.	20
Roads, paving and Concrete Pumps.	50

This initial rate of sampling shall be increased if either consistently high or low qualities are achieved.

The minimum number of test cylinders to be prepared from each sample shall be nine, three for testing at age 3 days, three at age 7 days and three at

28 days, the average of each of the three results being taken as the test result.

Acceptance criteria for both preliminary mix design test cylinders and construction quality control test cubes shall be as defined in ACI 318.

The strength of cylinders tested at 7 and 28 days shall be no less than 75% of the concrete strength specified.

CONTRACTOR shall maintain at SITE a complete and up-to-date set of records of all control test results and these shall be made available to PTT/CONSULTANT as required and shall be subject to his sign for review and comment.

5.5.5 Concrete Mixes

The required mixes shall be designed in accordance with the requirements of ACI 318 and Thailand Industrial Standard 213:2552

5.5.5.1 Trial Mixes

Unless there is existing data showing that the proposed mix proportions will produce the Grade of concrete required with adequate workability for full compaction by the methods to be used, trial mixes shall be prepared under full-scale conditions in accordance with the requirements of ACI 318.

5.5.5.2 Compliance with Specified Requirements

The compliance of a designed mix shall be judged by the strength of the hardened concrete in comparison with the specified characteristic strengths, together with the cement content in comparison with the specified minimum cement content and the maximum free water/cement ratio as specified in ACI 318.

5.5.5.3 Concrete Strength - Testing Plan

Compliance with the specified characteristic strength will be judged by tests made on Cylinder at 7 and 28 days.

5.5.5.4 Fresh Concrete - Testing Plan

Fresh concrete shall be sampled and tested in accordance with ASTM C143, 172 and 173.

One slump test on-site shall be performed at the start of each sections of the work and thereafter repeated as shown in **Table 2.**

The frequency of sampling at plant and on-site and testing air content in fresh concrete shall be each time a slump test is performed, or as required by PTT/CONSULTANT.

5.5.5.5 Non-Compliance with the Testing Plan

Should any cylinder test fall below the specified strength requirement, PTT/CONSULTANT will decide whether the concrete in the work represented by those cylinder can be accepted. Failing acceptance, CONTRACTOR shall carry out one or more of the following actions at its own expense:

a) Drilling and testing of cored cylinders in accordance with the procedures laid down in ACI 318 & ASTM C42.
b) Carrying out of load tests, or other non-destructive tests, in accordance with the procedures laid down in ACI 318.
c) Cutting out and replacement of defective concrete.

The action to be taken, size and location of cores for testing, the interpretation to be used for core strengths and the amount of cutting out shall be in accordance to the Standards.

5.5.5.6 Records

Records shall be kept by CONTRACTOR and a copy supplied to PTT/CONSULTANT, of the position in the Works of all batches of concrete, their Grade, and of the results of all test cubes, cores and other specimens taken from them.

5.5.5.7 Ready-mixed Concrete

Ready-mixed concrete may be used provided that it is produced at a plant approved by PTT/CONSULTANT, and that it complies with ACI 318 and ASTM C94 and TIS 213:2552.

PTT/CONSULTANT shall be afforded access to all parts of the ready mixed concrete plant during working hours.

The ready-mixed concrete supplier's statements on the cement content per unit volume of compacted concrete and on proposed admixtures shall be communicated in writing to CONTRACTOR before any concrete is delivered.

All delivery notes shall be retained by CONTRACTOR.

5.5.5.8 Transporting

Concrete shall be transported in accordance with ACI 304 which ensures that at the point of deposition it is of the correct quality and consistency.

Concrete delivery trucks used for transporting concrete shall incorporate means of agitating the concrete during transport to site.

Containers used for the transporting of concrete made from Portland Cement shall be free from any concrete or mortar containing either of the other types of cement.

5.6 Placing

Concrete shall be compacted in its final position as soon as practicable after mixing. Compaction shall take place within 30 minutes from the time when agitation of the mix has ceased. When ready mixed concrete is supplied in purpose made agitators, the time between the introduction of cement to the mix and compaction shall not exceed 2 hours.

Water shall not be added to the mix after the concrete has left the mixer. Concreting shall be carried out continuously up to all joints. The sequence of placing shall be such that trapped bays are not formed which would result in cracking due to drying shrinkage.

Concrete shall not be placed in any part of the structure until the formwork, staging, reinforcement and any built in items have been inspected. Spaces to be occupied by concrete shall be clean and free from water.

Concrete shall not be dropped freely from a distance of more than 1.5m, to avoid segregation, displacement of reinforcement, built in items, or movement of, and damage to faces of formwork.

- The use of chutes, spouts or pumps will be permitted. When flexible chutes are used they shall be kept free from coatings or hardened concrete.
-

Concrete shall be placed in layers that are approximately horizontal and not exceeding 450mm in depth. The height of lift and the rate of placement shall be determined by CONTRACTOR with consideration being given to the interval between successive layers, air temperature, method of compaction and temperature rise due to the heat of hydration.

At all times when concrete is being placed, a competent steel fixer shall be in continuous attendance to adjust and correct the position of any reinforcement which may be displaced.

Placing of concrete shall not be carried out in heavy rain, unless special precautions are put into force.

When vertical lifts of concrete are interrupted and delayed for more than one hour, but less than three hours, the surface of the unfinished concrete shall be thoroughly cleaned by air/water spray under pressure and concreting operations commenced immediately. The first layer of new concrete placed shall not exceed 150mm in depth and particular care shall be taken with compaction of this layer to ensure a good bond between the already cast concrete and the first new layer of concrete.

If concrete pouring of one structure is interrupted for more than 1 hour, contractor shall prepare to install construction joints and stop-end at concrete breaking point in case concrete poured.

Laying of thin sections such as floor slabs in two courses or layers shall not be permitted.

Reinforced concrete shall not be placed directly upon the ground. Where blinding concrete is used as a base it shall be Class 140, not less than 50mm thick, or as stated on the drawings, and laid over the ground immediately after excavation to provide a clean working surface.

Under yard paving, 0.15 mm thick heavy duty polythene sheet may be used instead of concrete blinding. Polythene sheet shall be laid in the longest lengths and widest widths available with overlaps not less than 150mm at all joints and intersections. Polythene sheet shall be laid on a surface free of hard spots or projections likely to cause a puncture.

Structural concrete cast against open excavated faces shall be as detailed on the drawings.

5.7 Compaction and Vibration

Full compaction of the concrete shall be achieved throughout the entire depth of the layer. It shall be thoroughly worked against the formwork, around the reinforcement and successive layers shall be thoroughly worked together, to form a solid mass free from voids.

Power driven vibrators shall be inserted at such distances apart or applied in such a manner as will ensure that the concrete is satisfactorily and uniformly compacted.

Immersion vibrators shall penetrate the full depth of the layer, and when the underlying layer is of fresh concrete, shall enter and re-vibrate that layer to ensure that successive layers merge together.

Vibration shall be carried out in a manner which does not promote segregation of the concrete.

Immersion vibrators shall be withdrawn slowly to prevent the formation of voids. Vibrators shall not be used to work the concrete along the forms, or in such a way as to damage formwork or other parts of the work, or displace the reinforcement.

Whenever vibration has to be applied externally the design of formwork and disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes.

Prior to the commencement of the works CONTRACTOR shall demonstrate the efficiency of his proposed method of on a trial section of the construction. Sufficient vibrators in serviceable condition shall be on SITE so that spare equipment is always available in the event of breakdowns.

Compaction shall not be achieved by vibration of the reinforcement.

5.8 Protection and Curing

Protection and curing shall be carried out in accordance with the requirements of ASTM C171. Immediately after finishing or removal of formwork, the exposed surfaces of the concrete shall be protected during hardening from the effects of sun, drying winds, rain or running water. Until after the initial set of the concrete the means of protection used shall not be supported from the concrete.

Curing of concrete after the initial set shall be by a method such that adequate water is available for full hydration of the cement. This may be attained by keeping the surfaces of the concrete wet by covering with a layer of sacking, or a similar absorbent material, such as sand, which must be kept soaked with water applied as a fine spray.

Alternatively, after thoroughly wetting the surfaces they shall be covered with an approved waterproof paper or plastic membrane kept in contact with the concrete, or immediately after placing of the concrete or removal of the forms applying to the concrete surfaces with an approved concrete curing compound, containing a dye, strictly in accordance with the manufacturer's instructions. Liquid curing membranes shall not be applied to surfaces which will later receive grout.

Concrete shall be cured for a minimum period of 7 days. During the curing cycle the concrete shall be protected from damage by shock, vibration, water or any agent likely to interfere with the process of setting and hardening. Loads of any kind shall not be placed on the concrete during the curing period without permission from PTT/CONSULTANT.

CONTRACTOR shall ensure that heat of hydration during curing of concrete shall not cause a temperature differential between the interior of the concrete and any outside face greater than 20^0C. This requirement shall apply to large pours which are those with thickness greater than 1.50m and minimum volume of $20m^3$.

Prior to pouring of any concrete CONTRACTOR shall submit to PTT/CONSULTANT details of temperature differential control procedure. When required by PTT/CONSULTANT CONTRACTOR shall prove the differential using embedded thermocouples for at least 10 days after the concrete pour and also the anticipated differential by calculation.

5.9 Control of Colour

Where uniformity of colour is important all materials shall be obtained from single consistent sources. The aggregates shall be durable and free of any impurities which may cause staining. The mix proportions and the grading, particularly of the fine aggregate, shall remain constant.

5.10 Construction Joints

Construction joints shall only be placed at the positions shown on the drawings.

Vertical construction joints shall be prepared by careful stripping of the stop end as soon as possible, within 12 hours, and the surface of the concrete immediately brushed with a wire brush to expose the aggregate. Care shall be taken only to remove the latency and not to loosen the aggregate.

Horizontal joints shall be prepared while the concrete is still not completely set. The surface skin shall be removed by means of an air-and-water jet to expose the aggregate and the surface left clean to receive further concrete. This operation shall be carried out within one hour after compaction and concrete pouring process is interrupted.

When it is impractical to carry out the above procedures the joints shall be prepared by needle gun to remove the surface skin and latency. Hacking of hardened surfaces shall be avoided. Before commencing with the fixing of reinforcement or shuttering for the new concrete, the surface of the hardened concrete shall be inspected by CONTRACTOR.

On completion of the fixing of reinforcement and the erection of formwork for the next lift of concrete, the horizontal and vertical construction joints shall be thoroughly cleaned of all dirt and debris.

Immediately before concreting is resumed, the joint shall be wetted with clean water. All surplus water shall be removed before start of concreting.

Reinforcement shall run continuously through construction joints unless noted otherwise on the drawings.

Vertical and horizontal construction joints in liquid retaining structures shall be provided with PVC water stop with at least width is 8 inch.

Extra care shall be taken at joints where PVC water stop is inserted. Care shall be taken not to damage or perforate the water stop by mishandling or nailing. Water stop shall be securely held in place so that they do not move during the placing of the concrete. The concrete shall be carefully placed and vibrated around the water stop and a complete bond formed between the concrete and all embedded areas of the water stop. Water stop shall be protected from the sun and the weather if the adjoining concrete is not to be placed within two weeks.

All junctions in water stop shall be formed using factory made intersections. Butt jointing only, between similar sections shall be carried out on site in accordance with the manufacturer's written instructions.

5.11 Expansion Joints

Expansion joints shall be located as indicated on the drawings. Reinforcement or other embedded items shall not be permitted to extend continuously through any expansion joint.

The joints shall be filled with an approved compressible material and joint sealant to the strict manufacturer's instructions. Joint sealant to be chemical resistance as indicated on the relevant construction drawings.

5.12 Surface Finishes

All concrete surfaces shall be free from honeycombing or other blemishes.

Unless specified elsewhere the exposed surface of road and floor slabs shall be properly tamped, using a vibrating or hand operated beam. Immediately after tamping, the completed surfaces shall be checked for flatness.

Any irregularities exceeding permissible tolerances shall be corrected. Irregularities shall not be made good after the concrete has set.

Concrete surfaces which are to receive grout shall be finished level and tamped. When the concrete has become firm but is still 'green', the surface shall be hosed and lightly brushed to remove latency and to expose the aggregate.

Other horizontal surfaces of concrete shall be uniform, level or sloped in accordance with the levels shown on the drawings. After the concrete has hardened sufficiently, the surface shall be wood floated sufficiently to produce a uniform surface free from screed marks. Concrete surfaces to receive chemical resistant coating, per standard 13241-83A10, shall be steel trowel finish and the surface shall be flat to a tolerance of +3mm in 3m.

5.13 Intervals During Concreting

The placing of concrete is to be arranged so that no face of concrete shall be left more than one hour before fresh concrete is placed against it. Pauses for meals, changes of shifts etc. and the distribution of the concrete to positions where work may be proceeding simultaneously shall be carefully organised to ensure that the above mentioned interval is not exceeded, except at construction joints.

5.14 Concreting During Hot Weather (Hot Climates)

Concreting in hot climates shall be carried out in accordance with the recommendations in ACI 305.

5.15 Reinforcement Workmanship

5.15.1 Placing

The number, size, form and position of all reinforcement shall be strictly in accordance with the drawings.

All reinforcement shall be free from loose rust, mill scale, oil and any other substance likely to reduce the strength or durability of the bond between the steel and concrete.

Black annealed steel binding wire of 1.5mm thickness shall be used for fixing the reinforcing material. The ends of the binding wire shall be tucked in to prevent corrosion spots in the concrete.

5.15.2 Cutting and Bending

Cutting and bending of reinforcement shall comply with ACI 318 (Chapter 7).

5.15.3 Fixing

Steel reinforcement shall be erected such as to form a rigid cage within the formwork, with every intersection being bound together with an approved binding wire which shall be tied in such a manner that the ends of the wire point inward to maintain the full specified cover. Steel stools of an approved diameter and spacing shall be provided between layers of reinforcement where necessary to maintain the required positions.

Specified concrete cover shall be maintained by the use of precast concrete spacer blocks of the same 28 day strength as the concrete in which they are to be used.

Two adjacent sheets of fabric reinforcement shall overlap by at least 300mm or 40 times the diameter of the wires lying at right-angles to the edges to be lapped, whichever of these dimensions is the greater.

Laps shall be tied together on both the longitudinal and transverse wires.

5.15.4 Welding

Welding of reinforcement shall comply with ACI 318 (Clause 3.5). Field welding of crossing bars is not permitted.

5.15.5 Testing

One sample of three test pieces per bar diameter per consignment received on SITE or fabrication works shall be tested by third party for tensile, bending and re-bend properties. A copy of the test certificates shall be sent to PTT/CONSULTANT.

5.16 Formwork Workmanship

5.16.1 Design

Formwork shall be designed and constructed in accordance with ACI 318. CONTRACTOR shall submit to PTT/CONSULTANT, for review, calculations and drawings of the formwork before formwork construction commences.

Formwork shall take due account of the surface finish required, and shall be sufficiently rigid and tight to prevent loss of grout from the concrete, and for the method of placing and compacting.

Choice of materials to construct formwork shall depend on climatic conditions and expected heat of hydration.

All edges of exposed concrete member shall have a 45° chamfer of approximately 25mm.

5.16.2 Construction

All formwork shall be set out accurately from datum and benchmarks. The correct position, level and alignment of all parts of the work shall be ensured by CONTRACTOR at all times during the execution of the works.

Formwork (including props) shall be so constructed that the forms are maintained in their correct position, and to correct shape and profile, so that the final concrete member is within the dimensional tolerances required by Clause 5.9 of this Standard.

Formwork shall be so designed as to be readily dismantled and removed without shock, disturbance or damage to the concrete. Where necessary, formwork shall be so arranged that the soffit form, adequately supported on props only, can be retained in position for such period as may be required by curing conditions or specification.

5.16.3 Internal Ties

No part of any formwork tie or spacer, remaining permanently embedded in the concrete, shall be less than 50mm from the finished surface. Ties which when removed leave a through hole in the member shall not be permitted in liquid retaining structures.

5.16.4 Preparation for Concreting

All rubbish and water shall be removed from the interior of the forms before the concrete is placed. Temporary openings shall be provided to facilitate cleaning and inspection of deep members.

5.16.5 Removal of Formwork

All formwork shall be removed in accordance with ACI 318 in a manner such that the concrete is not damaged in any way. **Table 3** below gives a guide to the minimum time period which will generally be required between placing the concrete and removing the formwork for Ordinary Portland Cement concrete. Notwithstanding compliance with these minimum times, CONTRACTOR shall be rectify any damage caused during removal of props and formwork.

Provided the concrete strength is confirmed by tests on cubes formwork supporting cast in situ concrete in flexure may be removed provided that such removal will not result in unacceptable deflections due to shrinkage, creep, etc.

TABLE 3 FORMWORK REMOVAL TIMES

TYPE OF FORM WORK	MINIMUM PERIOD BEFORE REMOVING, WITH SURFACE TEMPERATURE OF CONCRETE	
	16^0C	35^0C
<u>Vertical formwork to</u> Columns, walls and Large beams	2 days	2 days
Soffit formwork to slabs	7 days	7 days
Props to slabs	14 days	14 days
Soffit formwork to beams	14 days	14 days
Props to beams	14 days	14 days

Incase formwork removal cannot comply the time as per Table 3, cylinder compressive strength shall be as minimum

TYPE OF FORM WORK	MINIMUM CYLINDER COMPRESSIVE STRENGTH

Vertical formwork to Columns, walls and Large beams	50 ksc
Soffit formwork to slabs	140 ksc
Props to slabs	140 ksc
Soffit formwork to beams	140 ksc
Props to beams	140 ksc

5.16.6 Release Agents

Release agents for formwork shall be carefully chosen for the particular conditions they are required to fulfil. Where a concrete surface is to be permanently exposed the same agent shall be used throughout the entire area. Release agents shall be applied evenly and shall not be allowed to come in contact with reinforcement. Where the surface is to receive an applied finish, care shall be taken to ensure the compatibility of the release agent with the finish.

5.16.7 Surface Finishes from Formwork or Moulds

Surface finishes of formwork will be Type A, Type B or Type C. Type A being used below grade level and Type B above grade level. Type C may be required in Administration and Control Buildings.

Smooth off-the form and board-marked finishes are not to be used for external use, but where they are specified for interior use the following types may be quoted for the guidance of both designers and contractors. It should be appreciated that it is virtually impossible to achieve dense, flat smooth, even coloured, blemish-free concrete surfaces directly from the formwork. Some degree of making good is inevitable, even with precast work.

a) Type A Finish : This is obtained by the use of formwork or moulds of timber, plywood, plastics, concrete or steel. Small blemishes caused by entrapped air or water may be expected, but the surface shall be free from voids, honeycombing or other blemishes.

b) Type B Finish : This finish can only be obtained by the use of high quality concrete and formwork. The concrete should be thoroughly compacted and all surfaces should be true, with clean arises. Only very minor, surface blemishes shall be allowed, with no staining or discoloration from the release agent.

c) Type C Finish : This finish is obtained by first producing a Type B finish. The surface is then improved by removing all fins and other projections, thoroughly washing down and then filling the most noticeable surface blemishes with a cement and fine aggregate paste to match the colour of the original concrete. The release agent shall be carefully chosen to ensure that the concrete surface will not be stained or discoloured. After the concrete has been cured, the face shall be rubbed down, where necessary, to produce a smooth and even surface.

Where finishes other than Type A and B are specified, samples of surfaces of adequate size, incorporating a horizontal and vertical joint shall be made available for approval before work commences.

5.17 Precast Concrete Work (Excluding Pipes)

The requirements for concrete and reinforcement will be observed in the cast of precast concrete insofar as they are applicable, as well as the following:

a) All precast concrete shall, unless particularly specified to the contrary, be mechanically vibrated.

b) The yard in which precasting work is to be undertaken shall be to the approval of PTT/CONSULTANT.

c) Where precast units have projecting reinforcement the moulds shall, if necessary, be raised on stools above the grade level of the precasting yard.

d) The moulds shall be strongly constructed, closely jointed and true to the required shape with edges, corners and surfaces, which comply with the particular Specification. Moulds shall be so designed that they can be taken apart and reassembled with ease.

e) All units are to be marked on a face, which will not be exposed in the permanent Work with the date of manufacture and such distinguishing letters or numbers as required by the CONTRACTOR..

f) CONTRACTOR shall ensure that the following is followed for pre-cast concrete:

- The sides of the moulds may be removed not less than 12 hours after casting, provided the concrete has thoroughly.

- All concrete surfaces shall be curing by method in 5.8 for at least ten days during which time the surfaces shall be kept covered with hessian or other approved material.
- Slinging, transporting and stacking may take place ten days after casting, or as particularly specified. Building or setting into the works shall be at least 28 days after casting.
- The time periods specified above may be reduced where special techniques are adopted such as vacuum or pressed concrete, steam curing or when a rapid hardening cement is used shall be approved by PTT/CONSULTANT.

5.18 <u>Construction Tolerances for Concrete Work</u>

All concrete works shall be constructed within the tolerances specified in **Tables 4** and **5.**

5.18.1 Specific Tolerances

Pockets in Foundations
Maximum variation in size   +10 mm
Maximum deviation from specified location -   +6 mm

Level of Grouted Bearing Plates
Maximum deviation from specified level -   +0, -2 mm

Penetrations through floors, walls, etc
Maximum deviation in size and location -   +6 mm

TABLE 4
Range of deviations normally achievable for construction
(risk of non-compliance of approximately 1 in 22)

Item of construction		**Location**	**Construction material**	
			In situ concrete (mm)	**Precast concrete (mm)**
Size and shape Of elements and components	Walls	Height up to 3m	-	-
		Thickness	±8	-
		Straightness in 5m	±9	±6
		Abrupt changes in a continuous surface	±4	±3
		Verticality up to 2m	±11	±8
		up to 3m	±17	±11
		up to 7m	1G	±14
		Level of bed joints	NA	NA
	Columns	Size on plan up to 1m	±8	-
		Verticality up to 3m	±12	±10
		up to 7m	±16	±14
		Cased steel verticality up to 3m	NA	NA
		Squareness	±9	-

Item of construction		**Location**	**Construction material**	
			In situ concrete (mm)	**Precast concrete (mm)**
	Beams	Depth (Perimeter beams) up to 600mm over 600mm (Internal beams) up to 600mm over 600 mm Level Variation from target plane Straightness in 6 m	±13 ±20 ±12 ±16 ±22 ±10	- - - - ±23 ±8
	In-situ Flooring	Surface regularity Direct finished base slabs, toppings & screeds Variation from target plane Flatness Abrupt change across joints	±15 ±5 ±2	- -
Overall size	Building	Length or width up to 40m	±26	±38

TABLE 4

Range of deviations normally achievable for construction (risk of non-compliance of approximately 1 in 22) – Continued.

Position on plan in relation to the nearest reference line at the same level:		
(a) Foundations	$\pm$50	NA
Mass concrete in excavated ground with minimum formwork.	$\pm$50	$\pm$20
Reinforcement concrete including rafts,	$\pm$16	$\pm$14
ground beams, column bases, pile caps and	$\pm$12	$\pm$10
strip footings.	$\pm$12	$\pm$10
(b) Walls	$\pm$12	$\pm$10
(c) Structural frame-columns	$\pm$6	$\pm$ 6
(d) Finished stairs (flight from landing to landing)	$\pm$12	$\pm$10
(e) Door, window and other openings		
(f) Formers for items to be cast or built in		
(g) All other elements above foundations		
Dimensions on plan in relation to target sizes:		
(a) Foundations		
Mass concrete (as T1.5 (a))	$\pm$50	NA
Reinforced concrete (as T1.5(a))	$\pm$50	$\pm$10
(b) Structural frame length and width		
Up to 8m	$\pm$16	$\pm$12
Over 8m and up to 15m	$\pm$18	$\pm$16
Over 15m and up to 25m	$\pm$20	$\pm$18
(c) Stairs (finishes)		
Length of clear span	$\pm$12	$\pm$10
Width of flight	$\pm$10	$\pm$10

Levels - Range of deviations in level with reference to the nearest T.B.M.: (a) Foundations, Mass concrete Formation surface of excavation or blinding concrete Upper surface	 ±34 ±20	 - -
Reinforced concrete Formation surface of excavation or blinding concrete Upper surface	 ±30 ±16	 - -
(b) Concrete frame, Structural roof Upper surface height up to 30m For each subsequent 30m	±16 ±8	±20 ±10

TABLE 5

Range of deviations normally achievable for construction (risk of non-compliance of approximately 1 in 80)

Item	Type of dimension measured	Construction material			
		Precast reinforced concrete	Stop end plated	Formed or extruded	Inverted T-beams
		mm	mm	mm	mm
Overall size	Length up to 2m 2m to 6m 6m to 10m 10m to 20m 20m to 30m	 ±6 ±9 ±2 - -	 ±6 ±9 ±12 - -	 ±18 ±18 ±18 - -	 ±15 ±15 ±15 ±25 ±35
	Length up to 12m Height to apex	- -	- -	- -	- -
	Width or height up to 250mm 250mm to 1.25mm 1.25m to 4.0m	 ±4 ±6 ±8	 ±8 ±8 ±14	 ±8 ±8 -	 ±8 ±12 ±16
	Thickness or depth up to 0.5m 0.5m to 1.5m	±6 ±8	±7 -	±17 -	±17 ±17
Shape	Position and size of cut outs				

	and extensions up to 0.5m 0.5m to 10m	 ±6 ±12	 - -	 ±17 -	 ±17 ±17
	Squareness up to 1.2m 1.2m to 1.8m over 1.8m	 ±6 ±9 ±12	 - - -	 - - -	 ±12 - -
	Flatness	6 over a 1.5m length	-	-	-
	Position of internal holes up to 10m	±15	±15	-	±15

6.0 UNDERGROUND PIPEWORK

6.1 Scope

6.1.1 Pipework

This section covers the mandatory requirements for the installation, testing and commissioning of the following underground services:

a) Cooling water system
b) Firewater system
c) Service water system
d) Sanitary sewers
e) Oily waste water system
f) Drainage system
g) Chemical(Amine) waste water system

6.1.2 Associated Works

The work shall include the following:

a) Pipe bedding materials
b) Pipe protection materials
c) Pipe haunchings/surrounds
d) Manholes, chambers and ancillary drainage items
e) Process drain trench
f) Ditches and culverts

6.1.3 CONTRACTOR shall supply all the materials, mechanical plant, supervision and labour necessary to construct, test and commission the work defined on the drawings and in accordance with this Standard. All materials and workmanship shall comply with this Standard.

6.1.4 The excavation and backfilling of trenches for cables, drainage and underground services is covered in section 4.0.

6.2 Codes and Standards

All materials and workmanship shall comply with the following standards, unless otherwise specified herein:

6.2.1 Engineering Standards

ES-50.01	Design Instruction for Piping Arrangement
ES-50.02	Piping Material Specification

6.2.2 National/International Codes

AWWA C205-95	Cement-mortar Protective Lining and Coating for Steel Water Pipes
ASTM G24-96	Method for Cathodic Disbonding of Pipeline Coating Subjected to Elevated Temperature
SSPC-SP1	Solvent Cleaning
SSPC-SP11	Power-tool Cleaning to Bare Metal
NACE RP 0274-93	High Voltage Electrical Inspection of Pipeline Coatings prior to Installation
NACE RP 0287-95	Field Measurement of Surface Profile of Abrasive Blast-cleaned Steel Surfaces using a Replica Tape

6.3 Materials

6.3.1 General

MATERIALS		
SYSTEM	**MATERIAL**	**STANDARD**
Fire mains	Carbon Steel	Piping Material Class

		D1104**
Rainwater Water Sewer	Concrete pipe Carbon Steel	ASTM C76 ,ASTM C443 Piping Material Class D1101**
Cooling Water System	Carbon Steel	Piping Material Class D1101**

**Refer to Piping Engineering Standard ES-50.02

6.3.2 Materials for Pipework

All underground pipes, fittings and wrappings provided by CONTRACTOR for use in the works shall be shown on the drawings. CONTRACTOR shall obtain from the manufacturer certificates certifying that the pipes and fittings have been tested and comply with the appropriate Standard, before dispatch.

6.3.3 Materials for Concrete

Unless otherwise specified, all materials employed in the production of concrete shall comply with the requirements of section 5.0 of this Standard.

6.3.4 Materials for Bedding, Protection and Surrounding of Pipework

CONTRACTOR shall submit to PTT/CONSULTANT, proposals regarding the materials, their source and the method of installation. Sample loads of the proposed materials shall be delivered to the SITE for inspection and testing.

6.4 <u>Schedule of Materials</u>

6.4.1 Pipework

All free-issue underground pipework will be supplied with shop applied external coating of three-layer polyethylene. Fittings for the firewater system will be supplied with cement lining.

Valves with shop applied coatings located in pits below ground are deemed not to require further protection.

Where steel pipework is to be buried all external coatings will be 'holiday tested' in the installed position immediately prior to back filling, in accordance with section 6.4.5 of this standard.

Bends and fittings of NB less than 12" shall be protected by cold-applied tape.

6.4.2 Pipe Bedding

- Except where otherwise shown on the drawings, the bedding and surrounding of all pipework and trench backfilling shall be carried out using natural sand well graded and free from contamination and deleterious material in accordance with 4.8.1 of this standard.

6.4.3 Precast Concrete Manhole/Catch basin Rings

Manholes and catch basins shall be constructed utilising precast concrete rings and cover slabs which shall comply with the requirements of ASTM. A Class 140 concrete surround shall be provided to all such manholes where indicated on the Drawings.

Manholes shall have vertical steel ladders as defined on the detail drawings CONTRACTOR will be required to supply, fabricate and install these ladders.

6.4.4 Manhole Covers, Catch basin Gratings and Frames

CONTRACTOR shall supply and install manhole covers, catch basin gratings and frames, including drainage trench gratings, subject to approval by CONSULTANT.

6.4.5 Keys

CONTRACTOR shall hand over to PTT/CONSULTANT INITIAL ACCEPTANCE the lifting/locking keys.

6.4.6 Sand for Mortar

Sand for mortar shall comprise a natural washed sand or crushed natural stone or a combination thereof with naturally occurring sand, hard, clean and free from adherent coatings in accordance with section 5.3.6 of this standard.

6.4.7 Mortar Plasticizers

Plasticizers shall comply with ASTM C150 and shall be used in strict accordance with the manufacturer's instructions.

6.4.8 Factory Coated Carbon Steel Pipe

Material to be used in the coating of all site welded joints and damage on factory pre-coated buried steel pipes shall be in accordance with section 6.4.5 of this standard.

6.4.9 Reinforced concrete pipe and gaskets for culverts

Pipe shall be mesh or bar reinforced concrete to ASTM C76 with rubber compression gaskets to ASTM C443 and Contractor shall select the class of concrete pipe to withstand the load of backfill material and overburden load above ground.

6.5 Handling and Storage of Materials

6.5.1 General

All materials shall be stored in such a manner as to protect them from deterioration and contamination from whatever.

6.5.2 Material for Concrete

All materials used in the production of concrete shall be handled and stored in the manner described in section 5.4 of this Standard.

6.5.3 Pipework

All pipes and fittings shall be thoroughly inspected on delivery and again before being placed in position. Throughout the operations of delivery, handling, storing and transporting on or about the SITE, CONTRACTOR shall use such methods, plant and equipment as will prevent damage to the pipes and to any coating/lining. Impacts shall be avoided. Ropes, cables and hooks shall not be used during handling. Instead, wide leather or canvas straps shall be used and shall be of a length suited to the diameter of the pipes.

During storage, the pipes shall not be placed directly on the ground and shall not be stored one on top of another. They shall be placed on wide timber bearers with interplacing of a protective material such as straw rope felt or kraft paper strips and sacks of sand or sawdust.

Coated and wrapped carbon steel shall be protected from direct sunlight and all source which can damage coating material.

6.6 Workmanship

6.6.1 Excavation

Excavation for underground Pipework shall be carried out in accordance with section 4.0 of this Standard.

6.6.2 Levels

CONTRACTOR will be required to complete tie-ins to Existing Services as defined on the Drawings. CONTRACTOR is required to check the location, levels etc. prior to commencing work. Any discrepancies found shall be reported to PTT/CONSULTANT.

6.6.3 Bedding

A bed of selected backfill material shall be laid and compacted to 150mm thickness over the full width of the trench. Pipes shall be adjusted to line and level to ensure that pipe barrels rest uniformly on the bedding.

Where side fill is required, further selected backfill material shall be laid and compacted uniformly by hand halfway up each side of the pipes, pipes shall not be placed on Blocks, Bricks etc.

No variation from alignment or elevation shown on the drawings shall be allowed for pressure and gravity pipelines.

Pipes shall be laid so that each one is in contact with the bed throughout the length of its barrel, bedding material being scraped away at each socket in the case of socketed pipes so that the socket does not bear on the bed.

Pipes shall be laid with the spigot end in the outlet direction. Pipes shall be kept clean and open ends fitted with temporary stoppers to prevent ingress of foreign matter.

Backfilling shall not be undertaken until the installed pipeline has been tested, inspected.

6.6.4 Fabrication of Carbon Steel Piping

The pipe shall be supplied with a 150mm cut back on the coating and wrapping. The cut back is to allow welds to be completed on SITE. Fabrication of carbon steel pipes shall be in accordance with Piping Engineering Standard.

6.6.5 Protection of Carbon Steel Pipe and Pipe Joints

Protection and repair of damage to buried pipes shall be in accordance with Piping Engineering Standards.

6.6.6 Pipe laying and Installation

Before installation, the pipe shall be inspected for defects. Material found to be defective before or after laying shall be with sound material.
CONTRACTOR shall prepare and submit for PTT/CONSULTANT review and comment a detailed procedural description of his intended method for installing:

a) Underground contaminated and rainwater water systems.
b) Underground firewater main system.
c) Underground cooling water system.

The procedure shall incorporate the manufacturer's recommendations for laying and jointing of the pipework and fittings including ovality testing and correction. Also to be included will be CONTRACTORS proposed method of excavation, bedding, haunching or surrounding of pipelines and backfilling procedure.

As the work progresses, the interior of the pipe shall be cleared of all superfluous materials. As soon as possible after the joint is made, sufficient backfill material shall be placed along the pipe to prevent pipe movement of line or gradient.

CONTRACTOR shall ensure adequate bond in the cement linings of adjoining cement-lined piping components.

6.6.7 Back-filling to Pipework

Selected fill shall be laid in 150mm layers and hand compacted to a level 300mm above top of pipe followed by main backfill material placed and compacted in 300mm layers - any trench sheeting being withdrawn as the work proceeds. Mechanical compactors shall not be used until there is at least 450mm hand compacted cover over the crown of the pipes.

Temporary bridges shall be provided over trenches to carry construction

6.6.8 Manholes, etc

Manholes, valve chambers, catch basins, pump chambers etc shall be constructed at locations indicated on the drawings and in accordance with the details shown.

Bases to manholes, etc., shall be cast in concrete Class C24/28 minimum 150mm thick minimum, the size of the base shall be equal to the external dimensions of the manhole chamber. Precast concrete manholes shall be constructed with precast concrete sections complying with the relevant requirements of ASTM C478 & C923, with ogee joints. A chamber ring with openings for the drain inlets and outlets shall be set vertically on the manhole base, and subsequent sections added, as required, and set vertically, to build the manhole up to surface level.

All spun concrete manhole sections shall be supplied with suitable sealant at the joints to provide water-tight seals.

Bed top pre-cast concrete section dry pending completion of surrounding levels. Replace or adjust as necessary to give accurate and even final levels.

If CONTRACTOR wishes to install insitu constructed manholes and catch basins, the details shall be submitted to PTT/CONSULTANT for review and comment before to any construction taking place.

6.6.9 Bedding Manhole Cover Frames

Manhole cover frames shall be bedded as shown on the drawings.

All frames shall be solidly bedded such that the manhole cover is even with the surrounding finished surface. Any installed cover or frame not level or that allows rocking of the cover, shall be made good or replaced at CONTRACTOR's expenses.

6.6.10 Temporary Manhole Covers

Partly constructed manholes shall be protected with timber or metal temporary covers. Building debris being allowed to accumulate in chambers will require the associated pipe runs to be rodded out at CONTRACTOR's expense.

6.6.11 Sealing Pipe Open Ends

All pipe open ends and terminations for later connections of pipes shall be securely sealed, plugged or capped during progress of the works to prevent entry of foreign matter. Plastic, shaped hardwood, or metal plugs shall be used to plug drains. Screwed-up paper or cloths pushed into pipe ends will not be acceptable and shall not be used.
Building debris being allowed to accumulate in drains will require rodding and clearing out at CONTRACTOR's expense.

6.6.12 Display “confined space” warning sign at manholes in accordance with OSHA 1910.119.

6.7 <u>Testing</u>

6.7.1 Drainage and Sewer Pipework
An air test shall be undertaken by CONTRACTOR in accordance with clause 6.7.3 of this standard.

CONTRACTOR shall carry out a further test on completion of the backfilling and prior to the laying of concrete paving. The test shall be a water test in accordance with clause 6.7.2 of this standard and shall be from manhole to manhole, with branch lines being tested separately. The final test will be undertaken in the presence of PTT/CONSULTANT, this will be a water test as described in 6.7.2.

The drainage system will not be deemed to have failed by means of an air test. A water test shall be carried out prior to the rejection of the system.

Pipework failing the requirements of the water test will be taken up re-laid and re-jointed as necessary and tested again to establish water-tightness. All replacement of failed pipework will be at the expense of CONTRACTOR. All necessary apparatus and attendance for the tests shall be provided by CONTRACTOR.

For testing pipes larger than 900mm diameter CONTRACTOR may call in a specialist testing SUB-CONTRACTOR with the appropriate equipment. For man entry pipes special apparatus is available to test joints or short sections of pipe in situ.

6.7.2 Water Test

Testing of the drains shall be as follows:

The section of the drain to be tested shall be suitably stoppered or plugged at the end of connections. A test head shall be fixed at the higher end. This drain shall then be filled with water to a head of not less than 1.5m above the soffit of the pipe at the high end but not more than 2.4m at the low end. Steeply graded drains shall be tested in stages where the above maximum head would be exceeded if the whole section were tested at once.

Unless otherwise agreed by PTT/CONSULTANT, the test shall commence one hour after filling the test section, at which time the water level in the feed pipe shall be made up to produce the required test head. The test shall be continued for sufficient time to allow PTT/CONSULTANT to inspect the pipeline and satisfy himself regarding its water-tightness and in any case for not less than one hour. The loss of water over a 30 minute period shall be measured by adding water at regular 10 minute intervals to maintain the original water level and recording the amounts added. The drain will have passed the test if the volume of water added does not exceed one litre/hour per metre diameter per metre run.

6.7.3 Air Test

The section of the drain to be tested shall be suitably stoppered or plugged. A manometer shall be connected to one of the plugs and air pressure source shall be applied to another plug. Pressure shall be applied either by mouth or with a hand pump to achieve 100mm water gauge. The test apparatus shall be left for a minimum of five minutes. The head of water shall not fall more than 25mm in a period of five minutes for the test to be acceptable.

6.7.4 Manholes

Each manhole shall be tested for water-tightness in the presence of PTT/CONSULTANT by filling with water to level not exceeding 3m above the pipe soffit level and allow water to stand for a period of 8 hours for absorption; top up water level as necessary.

CONTRACTOR shall be responsible for locating, making good any leakages and the work will be accepted as satisfactory only when a visual inspection for water-tightness reveals no leaks or external damp patches. This test is to be carried out prior to the placing of the backfill materials.

6.7.5 Clear and Flush All Drains

Before completion of the works and prior to final test, CONTRACTOR shall clear out and flush all drains, manholes, etc., with water, rodding through drains where necessary to ensure clearance of debris and leave the system in clean working order with all traps sealed with water.

6.7.6 Firewater Main Pipework

The firewater system shall be hydraulically tested to 1.5 times the system's design pressure as follows:

Design Pressure 150 Psig

Test Pressure 225 Psig

The initial hydrostatic test shall be carried out on completion of the system or as sections of the installation are installed. The full test pressure shall be applied in this test. CONTRACTOR shall backfill over the pipe to the proposed underside of paving level, but leaving all joints visible for inspection. Where open ends occur, CONTRACTOR will install a restraint to stop any movement.

During the installation CONTRACTOR will install vent valves or suitable tappings at high points of the sections to be tested, to allow the expulsion of air whilst the main is being filled. If the pipe is on a level grade, it may be necessary to bleed air off at several points to ensure complete air evacuation. After the air has been released all vent holes shall be plugged prior to testing.

The test procedure shall be as follows: CONTRACTOR will fill the system with water at a steady rate, upon completion the system will stand for a period of 24 hours to complete the process of water absorption by the cement lining. The water level will be topped-up prior to pressurization of the system commences.

CONTRACTOR shall steadily pressurize the system up to the working pressure and stop until conditions stabilize. The pressure shall be steadily increased until test pressure has been achieved at the lowest point of the section under test. The pressure shall be maintained for one hour, pumping if necessary to keep the pressure stable. After one hour, disconnect the pump and leave for a further hour. If the test pressure has dropped at the end of the test period, restore the test pressure and measure the water loss by drawing off water from the pipe line until the pressure once again matches that at the end of the test period.

The water loss shall not exceed 0.2 litres per mm of nominal bore per kilometre of pipe line per 24 hours for each one bar head of pressure.

A final hydrostatic test shall be carried out by CONTRACTOR in the presence of PTT/CONSULTANT.

6.7.7 Process and Pressurized Pipework

Testing of carbon steel pipework shall comply with the requirements of ANSI B31.3 and Piping Engineering Standards.Test Program

CONTRACTOR shall submit to PTT/CONSULTANT for his prior approval, a testing program for all underground drainage and sewerage systems and pressure systems.

6.7.8 Record of Tests

CONTRACTOR shall keep a complete record of all tests carried out after construction in accordance with Piping Engineering Standards.

CONTRACTOR shall supply PTT/CONSULTANT with a copy of the records as the testing proceeds and at the end of the contract, or as otherwise requested by PTT/CONSULTANT.

6.7.9 Connections to existing pipelines shall be as shown on the drawings.

Manholes, catch basins, drainage items, valve chambers, pump chambers and thrust blocks shall be constructed as shown on the drawings.

All manholes, catch basins, valve chambers and pump chambers shall be water-tight on completion. Frames for manhole covers shall be set in cement mortar. Two sets of keys shall be delivered to CONSULTANT for each pattern of cover supplied.

6.7.10 Thrust Blocks

The location of thrust blocks shall be shown on the underground layouts.

The thrust blocks shall be constructed against undisturbed soil on completion of the excavation, the concrete being placed immediately to prevent instability of the excavation sides.

Where soil has been disturbed or in an unconsolidated state, the unsuitable material shall be removed for a distance of at least 5 pipe diameters from the face of the block to a depth of at least 3 pipe diameters underneath the block over an area of twice the size of the block.

The replacement fill material shall conform to clause 4.8.1 above and placed in layers of 150mm loose thickness and pneumatically rammed in accordance with clause 4.8.4 above.

On completion of the compaction of any fill material the thrust block shall be immediately cast.

6.7.11 Incomplete or Future Connections

Junction pipes which are laid, but not immediately connected, shall be fitted with temporary stoppers or seals and the position of all such junctions shall be clearly defined by means of stakes or tracing wires marked and labeled.

7.0 HOLDING DOWN BOLTS

7.1 Scope

This section covers the mandatory requirements for the installation of standard holding down bolts. Special bolts or additional installation requirements will be described on drawings.

7.1.1 All details of materials for manufacture of holding down bolts shall be shown on drawings.

7.2 Testing

One sample of three test pieces per bolt diameter per consignment received on SITE shall be tested by an independent testing laboratory.

7.3 Installation

7.3.1 All cast-in holding down bolts shall be accurately positioned using templates of suitably robust material supplied by CONTRACTOR.

7.3.2 The embedded portion of the holding down bolts shall be free from grease, oil, loose rust or mill scale prior to placing the concrete.

7.3.3 The portion of the holding down bolt projecting above the top of structural concrete level shall be wrapped in Densotape prior to placing the concrete. The threaded portion of the bolt shall be greased and the nuts and washers placed in position.

7.4 Holding down bolts setting out tolerances shall comply with the following:

Centre of bolt	+3mm
Group location	+10mm
Projection	+25mm - 5mm
Level of underside of base plate	+10mm

7.5 Holding down bolts are not designed to be pre-tensioned unless noted otherwise on the detail drawings. Nuts are to be tightened up to a ‘snug fit’ and then locked with a lock nut where specified on the detail drawings.

8.0 GROUTING

8.1 Scope

This section covers the mandatory requirements for the supply and installation of all grouting work.
The type, thickness and areas of grout shall be in accordance with the drawings.

8.2 Types of Grout

Type G1

This is a proprietary, non-shrink, non-metallic, fluid grout, shall be used and mixed strictly in accordance with manufacturer’s instructions. CONTRACTOR may propose an alternative VENDOR, which shall be subject to approval by PTT/CONSULTANT.

Type G2

This is a proprietary epoxy grout or an approved equal shall be used and mixed strictly in accordance with manufacturer’s instructions. CONTRACTOR may propose an alternative VENDOR, which shall be subject to approval by PTT/CONSULTANT.

Type G3

This is a cement/sand grout with a water/cement ratio of not greater than 0.5 and a compressive strength of 280 ksc at 7 days in accordance with ASTM C109.

When Type G3 grout is to be used over a large area, a suitable plasticizer approved by PTT/CONSULTANT may be added in accordance with the manufacturer’s instructions.

Three test cylinder shall be tested for each 1m^3 of Type G3 grout that is used. The tests will be in accordance with ASTM C109.

Grout for screeding and dry packing

This is a cement/sand grout with a ratio of cement to sand of 1:3 in the mix, water/cement ratio not greater than 0.5 and a compressive strength of 150 ksc at 7 days in accordance with ASTM C109.

8.3 Preparation

8.3.1 Concrete surfaces, which are to receive grout, shall be finished level and reasonably smooth by tamping. When the concrete has become firm but is still green, it shall be hosed and lightly brushed to remove latency and expose the aggregate without disturbing it.

8.3.2 The surface shall be cleared of all defective concrete and latency, oil, grease and other chemicals and dirt.

8.3.3 Bolt sleeves shall be freed of all static water, polystyrene formers and foreign matter, before grouting takes place.

8.3.4 All grout shall be placed within shuttering. Shuttering shall be of adequate strength and securely fixed to withstand the pressure of the grout and be sealed to prevent leakage.

8.3.5 Grout shall be placed as soon as possible on the underside of the skid or base plate after the installation and alignment of the equipment or steelwork.

8.3.6 Proprietary grouts shall be mixed and prepared strictly in accordance with the manufacturer's instructions.

8.3.7 Foundations to receive water-mix grout shall be kept wet for 24 hours before the grout is placed, and care taken to remove all free water before placing.

8.4 Placing

8.4.1 Remove all laitance, other loose materials, and oil soaked, or damaged concrete from the surface of concrete to receive grout by brushing, cleaning or chipping. Leave the surface rough and irregular with an amplitude of 6 mm to provide a good bond.

The elevation of the top of concrete shall be such as to allow for the grout thickness between the machines or structure base and the concrete as called for on the design drawings. Clean sole plates, base plates, and other metal surfaces which will be in contact with the grout. Cover leveling screws and shims or wedges to be removed with a lubricant to prevent the grout from adhering. Mask off or oil areas which require protection from grout or splatter. For cement grout, wet the surface before grouting, but remove free water from the concrete surface and out of bolt holes.

Care shall be taken to ensure that the grout completely fills the void to be grouted and is thoroughly compacted and free from air pockets. Any areas or pockets which are not to receive grout shall be sealed with an approved material.

8.4.2 All bolt holes and sleeves shall be filled adequately and pressure grouting used where necessary. Steel shims shall be encased by grout with at least a 20mm cover.

8.4.3 All proprietary grouts shall be placed strictly in accordance with the manufacturer's installation procedures.

8.4.4 Grouts shall be cured for a minimum of four hours.

8.5 Finishing

8.5.1 After a suitable curing period, the works shall be neatly pointed and trowelled off and left in a workmanlike manner.

8.5.2 Exposed edges shall be protected adequately against damage and the effects of the elements during the curing period.

All exposed grout shall be provided with a 25mm wide finished shoulder sloped at about 45° unless otherwise directed.

9.0 COMPACTION REQUIREMENTS FOR EARTHWORKS

Compaction requirements shall be in accordance with **Table 6**.

TABLE 6 - COMPACTION REQUIREMENTS

TYPE OF COMPACTION PLANT	CATEGORY	COHESIVE SOILS		WELL GRADED GRANULAR AND DRY COHESIVE SOILS (CRUSHED ROCK, SAND)		UNIFORMLY GRADED MATERIAL	
		Maximum depth of compacted layer in mm	Minimum number of passes	Maximum depth of compacted layer in mm	Minimum number of passes	Maximum depth of compacted layer in mm	Minimum number of passes
SMOOTH-WHEELED ROLLER	MASS PER METRE WIDTH OF ROLLER						
	over 2100 kg up to 2700 kg	125	8	125	10	125	10*
	over 2700 kg up to 5400 kg	125	6	125	8	125	8*
	over 5400 kg	150	4	150	8	Unsuitable	
PNEUMATIC TYRED ROLLER	MASS PER WHEEL						
	over 1000 kg up to 1500 kg	125	6	Unsuitable		150	10*
	over 1500 kg up to 2000 kg	150	5	Unsuitable		Unsuitable	
	over 2000 kg up to 2500 kg	175	4	125	12	Unsuitable	
	over 2500 kg up to 4000 kg	225	4	125	10	Unsuitable	
	over 4000 kg up to 6000 kg	300	4	125	10	Unsuitable	
	over 6000 kg up to 8000 kg	350	4	150	8	Unsuitable	
	over 8000 kg up to 1200 kg	400	4	150	8	Unsuitable	
	over 12000 kg	450	4	175	6	Unsuitable	
VIBRATING ROLLER	MASS PER METRE WIDTH OF A VIBRATING ROLLER						
	over 270 kg up to 450 kg	Unsuitable		75	16	150	16
	over 450kg up to 700 kg	Unsuitable		75	12	150	12
	over 700 kg up to 1300 kg	100	12	125	12	150	6
	over 1300 kg up to 1800 kg	125	8	150	8	200	10*
	over 1800 kg up to 2300 kg	150	4	150	4	225	12*
	over 2300 kg up to 2900 kg	175	4	175	4	250	10*
	over 2900 kg up to 3600 kg	200	4	200	4	275	8*
	over 3600 kg up to 4300 kg	225	4	225	4	300	8*
	over 4300 kg up to 5000 kg	250	4	250	4	300	6*
	over 5000 kg	275	4	275	4	300	4
VIBRATING PLATE COMPACTOR	MASS PER UNIT AREA OF BASE PLATE						
	over 880 kg up to 1100 kg	Unsuitable		Unsuitable		75	6
	over 1100 kg up to 1200 kg	Unsuitable		75	10	100	6
	over 1200 kg up to 1400 kg	Unsuitable		75	6	150	6
	over 1400 kg up to 1800 kg	100	6	125	6	150	4
	over 1800 kg up to 2100 kg	150	6	150	5	200	4
	over 2100 kg	200	6	200	5	250	4
VIBROTAMPER	MASS						
	over 50 kg up to 65 kg	100	3	100	3	150	3
	over 65 kg up to 75 kg	125	3	125	3	200	3
	over 75 kg	200	3	150	3	225	3
POWER RAMMER	MASS						
	100 kg up to 500 kg	150	4	150	6	Unsuitable	
	over 500 kg	275	8	275	12	Unsuitable	

For items marked * the rollers shall be towed by track-laying tractors. Self propelled rollers are unsuitable.

Definitions and Requirements associated with Table 6.

1. The depth of compacted layer is the height by which the embankment is raised by each successive compacted layer.

2. The number of passes is the number of times that each point on the surface of the layer being compacted has been traversed by the item of compaction plant.

3. The compactive effort of each compactor is a function of the mass of the machine. The compaction plant in Table 3 is listed in terms of the mass per metre width roll width. Where a smooth-wheeled roller has more than one axle the machine shall be assessed on the basis of the axle giving the highest value of mass per metre width.

4. a) For pneumatic-tyred rollers, mass per wheel is the total mass of the roller divided by the number of wheels.

   b) In assessing the number of passes of pneumatic-tyred rollers, the effective width shall be the sum of the widths of the individual wheel tracks together with the sum of spacing between the wheel tracks provided that each spacing does not exceed 230mm the effective width shall be the sum of the widths of the individual wheel tracks only.

5. Vibrating rollers are self-propelled or towed smooth-wheeled rollers having means of applying mechanical vibration to one or more rolls.

   a) The requirements for vibrating rollers are based on the use of the lowest gear on a self-propelled machine with mechanical transmission and a speed of 1.5-2.5 km/h for a towed machine, or a self-propelled machine with hydrostatic transmission. If higher gears or speeds are used an increased number of passes shall be provided in proportion to the increase in speed of travel.

   b) Where the mechanical vibration is applied to two rolls in tandem, the minimum number of passes shall be half the number given in Table 3 for the appropriate mass per metre width of one vibrating roll. If one roll differs in mass per metre width from the other, the number of passes shall be calculated as for the roll with the smallest value.

      Alternatively the machine may be treated as having a single vibrating roll with a mass per metre width equal to that of the roll with the higher value.

   c) Vibrating type rollers operating without vibration shall be classified as smooth-wheeled rollers.

d) Vibrating rollers shall be operated with their vibratory mechanism operating only at the frequency of vibration recommended by the manufacturers. All such rollers shall be equipped or provided with a device automatically indicating the frequency at which the mechanism is operating.

6.Vibrating-plate compactors are machines having a base-plate to which is attached a source of vibration consisting of one or two eccentrically weighted shafts.

a) The mass per unit area of base-plate of a vibrating-plate compactor is calculated by dividing the total mass of the machine in its working condition by its area in contact with compacted soil.

b) Vibrating-plate compactors shall be operated at the frequency of vibration recommended by the manufacturer. They shall normally be operated at travelling speeds of less than 1 km/h but if higher speeds are necessary the number of passes shall be increased in proportion to the increase in speed of travel.

7. Vibro-tampers are machines in which an engine-driven reciprocating mechanism acts on a spring system through which oscillations are set up in a base-plate.

8. Power rammers are machines which are actuated by explosions in an internal combustion cylinder, each explosion being controlled manually by the operator.

9. In the case of power rammers one pass will be considered as made when the compacting shoe has made one strike on the area in question.

10. For items marked * the rollers shall be towed by track-laying tractors.

Self-propelled rollers are unsuitable.

REVISION	REV 0	REV 01	REV 02	REV 03	REV 04
DATE	SEP 30, 04	NOV 15, 05	OCT 28,15		
ORIG.BY	WORATAT B.	WISUT N.	Witthawat K.		
APP.BY					
SIGNATURE					

CONTENTS

SECTION **SUBJECT**

1.0 GENERAL

1.1 Scope

This specification covers the mandatory requirements for the design, performance and installation of the electrical and telecommunication systems and facilities, together with the applicable standards and codes of the whole gas plant.

Contractor's scope of supply and services shall be considered as specified in Part C Section III, Item 2, GENERAL ENGINEERING AND DESIGN REQUIREMENTS, of ITB.

1.2 Standards and Codes

All laws, regulations, standards and codes and engineering practices to be observed shall be the actual issue or date prior to bidding date.

The following standards and codes shall be used together with this specification for the design, manufacture and testing of electrical systems and equipment as well as their installation:

a) Project specific standard as follows:-

- ES-70.02.01 HV Switchgear
- ES-70.02.02 LV Switchgear
- ES-70.02.03 Transformers
- ES-70.02.05 Power capacitors
- ES-70.02.06 Uninterruptible Power Supplies (UPS)
- ES-70.02.07 Synchronous Generator
- ES-70.02.08 Diesel Generator set
- ES-70.02.09 Motors
- ES-70.02.10 Wound Rotor induction Motor
- ES-70.02.11 Power management System (PMS)
- ES-70.02.20 Variable Speed Drive Specification
- ES-70.02.21 Cable Specification
- ES-70.02.04 Neutral Earthing Resistance
- ES-80.02.13 Telephone System PABX
- ES-80.02.14 Public Address and Alarm System
- ES-80.02.15 Closed Circuit TV System (CCTV)
- ES-80.02.17 Local Radio System (LORS)

- ES-92.07 Cathodic protection
- ES-95.70 Inspection and test of electrical equipment

b) Generally for the engineering IEC, ISO, CENELEC, API, NFPA, IEEE, NEC , CIE design and wherever possible.

c) Local Vendor, entire CTNSS, NEA, TISI installation

d) Foreign Vendor, depending on the country of origin of equipment

- France NF, UTE
- Germany DIN, VDE, VDI
- Italy CEI, CESI
- Japan JEC, JEM, JCS, RIIS
- United Kingdom BASEEFA, BS, CP, IEE
- Australia SAA, AS
- USA ANSI, IEEE, NEC, NEMA

e) For telecommunication

Additionally to the standards and codes specified under 1, 2 and 3 above

- International Telephone CCITT
- International Radio Consultative Committee CCIR

f) Electrical graphical symbols shall be in accordance with the relevant sections of IEC 60117.

g) For lightning protection design NFPA 78

h) For protection relay shall be in accordance with the relevant sections of following standards

- IEC 60255
- IEEE 242

The SI (metric) system of units shall be used wherever practicable.

In the event of conflicting requirements between this specification and the referenced codes and standards, the most stringent requirements shall prevail. In any case, this shall be brought to the attention of PTT/CONSULTANT.

1.3 Hazardous Areas

Classification of hazardous areas shall be performed in accordance with NEC (National Electrical Code/USA). The extent of classified areas shall conform to API RP 500 A/B/C. The Contractor shall perform Hazardous Area Classification for information and reference only and not to be used for equipment selection and installation.

All Equipment and installation in the Scope of Project shall be considered as being located within hazardous areas and shall satisfy minimum conditions as per Table 1.3-1.

Explosion-proof-type equipment shall be certified by an authorized institute in accordance with the applicable ATEX, CENELEC, NEC/UL or RIIS procedures.

Table 1.3-1: Minimum Required Type of Protection for Equipment in Hazardous Areas

	Class I, Division 1	**Class I, Division 2**
1. Squirrel-cage induction motors	Explosion (flame) proof (Exd)	Increased safety (Exe)
2. Slip-ring or commutator type motors	Explosion-(flame)-proof (Exd) or pressurized (Exp)	
3. Switching and control equipment	Explosion-(flame)-proof (Exd) or Increased safety (Exe)	
4. Lighting fixtures	Explosion-(flame)-proof (Exd)	
5. Communication equipment	Explosion-(flame)-proof (Exd) or Increased safety (Exe)	
6. Terminal boxes	Increased safety (Exe) or explosion-(flame)-proof (Exd)	

1) Slip-ring device of wound rotor induction motors shall be arranged within individual enclosure certified as flameproof or pressurized equipment.

1.4 Climatic data

The design and performance of electrical systems and equipment shall be based on the Basis Engineering Design Data (BEDD), doc. No. ES-99.00.05.

1.5 Equipment and Material

Equipment shall be obtained from reliable and established vendor. Prototype material and equipment are not acceptable.

Equipment and materials shall be suitable for use in humid tropical industrial climates and be protected against the influence of climate, corrosive substances in the ambient area, fungi and rottenness. It shall be furnished with all necessary weather and anticorrosion protection such as canopy to prevent damages caused by that influence. Outdoor electrical equipment such as motors, motor terminal boxes, local control stations, lighting fixtures, telephone/paging & intercom handsets, junction boxes and etc. shall be provided with canopy to protect against sunlight and water.

The equipment shall be proof against ingress of birds, rodents, vermin and insects either by its own enclosure or by the design and performance of buildings if located indoors.

Equipment's enclosure and explosion-proof equipment shall be made of metallic materials only.

Electronic equipment's applied to use in all electrical equipment shall not be affected by radio frequency and electromagnetic interference. The overvoltage protection, e.g. surge protection, etc., shall also be provided for all electronic related parts, component and equipment.

Equipment, which shall accessible to personnel during its operation, shall not be designed and installed to come into contact with dangerous voltages, movable and rotating parts.

Substation shall be normally air-conditioned but the equipment shall be able to withstand the effects of temperature and humidity in the case of A.C. failure.

2.0 SYSTEM DESIGN

2.1 Basic Design Data and Considerations

Systems shall be designed, performed, operated and utilized as specified herein below.

2.1.1 Voltage Levels and System Design Data

No.	System Ratings	Grid Intake	Central-Substation	New Power Generation	New Primary Distribution	New Secondary Distribution
1	Nominal Voltage	115,22 kV	33 kV	11,6.9 kV	11,6.9 kV	400/230 V
2	Nominal frequency	50 Hz	50 Hz	50 Hz	50 Hz	50 Hz
3	Phases/wires	3/3	3/3	3/3	3/3	3/3 + N + PE
4	Neutral grounding	Solidly	Resistance	Resistance	Resistance	Solidly
5	Ground fault current	-	400 A – 10 s	400 A – 10 s	400 A–10 s	-
6	Voltage fluctuation - steady state - instantaneous	± 5 %	± 5 %	± 5% ± 10 %	± 5 % +10/-15 %	± 5 % +10/-15 %
7	Frequency fluctuation	±1Hz	±1Hz	± 1 Hz	± 1 Hz	± 1 Hz
8	Combined voltage and frequency fluctuation - steady state	+7/-8 %	+7/-8 %	+7/-8 %	+7/-8 %	+7/-8 %
9	Short-circuit fault Level 1) Max/min		-	-	-	-
10	Short-circuit fault Rating 2)	31.5 kArms-1s	40 kArms-1s	40 kArms - 1s	50 kArms-1s	80 kArms-1s
11	Power factor - natural - improved	0.9 lagging	0.8 lagging	0.8 lagging	0.8 lagging	0.8 lagging

Notes:

1) Initial symmetrical short-circuit power (S” $_{K3pol}$)
2) Rated breaking and short-time current
3) Nominal voltage 11.5kV primary distribution at OCS1 substation should refer in New Primary Distribution column

2.1.2 User Voltage

Users shall be provided for the following nominal voltages:

S. No	Date Type	Nominal Voltage
1	Induction motors	
1.1	Non-process motors up to 0.35 kW	220 V, 1-phase AC
1.2	Motors up to 159 kW	380 V, 3-phase AC
1.3	Motors 160 kW and over	6.6 kV,11kV , 3-phase AC
2	Motors actuators	380 V, 3-phase AC
3	Electrical resistance heaters	220 V, 1-phase AC, or 380 V, 3-phase AC
4	Lamps	220 V AC
5	Portable safety and maintenance lighting	24 V AC, phase-to-phase
6	Intermediate emergency and air-craft warning lighting	220 V, 1-phase AC, or 125 DC, isolated pole
7	Power and welding outlets	380 V, 3-phase AC
8	Small power and convenience outlets	220 V, 1-phase AC
9	DCS, PLC, ESD, critical instrumentation, SCADA system	220 V, 1-phase AC, or 24 V DC, grounded pole
10	Non-critical instrumentation	220 V, 1-phase AC
11	Electrical auxiliary and control circuits	
11.1	33kV, 22kV, 11kV system, and 400-V main incomes and bus tie	125 V DC, isolated pole
11.2	400/230 V system	220 V AC, 1-phase AC
12	Telecommunication systems, fire detection and alarm system	220 V, 1-phase AC, or 24 DC, grounded pole

Notes:

1) Nominal voltage 11.5kV Motor shall be referred as 1.3 and other 11 kV motor in this document

2.1.3 An electronic control system philosophy

For all power system equipments which equipped with an electronic control system, its power supply for control system shall have 2 (two) sources separately and independently. Each control source shall be able to operate as main and reserve. In the event that one supply source is tripped or shutdown for maintenance, another supply source shall act as reserve supply. The transfer functions from main to reserve supply source, and vice versa, shall be switching power supply to make smoothly transfer without any interruption.
Every electronic control panel, the enclosure shall have EMC certificate.

2.2 Configuration of Power Systems

2.2.1 The conceptual configuration of power systems shall be provided in accordance with the following principle one-line diagram, attached herewith:

- OCS1 Substation one-line diagram Dwg. No. 70-3-0904.01-310-SW-01-001
- PTT Central Substation Gas Turbine Generator Unit Dwg. No. 70-3-0704.00-3629-003
- Gas Separation Plant No.6 Overall Single Line Diagram Dwg. No. 70-1-0504.05-3628-002
- Ethane Gas Separation Plant Overall Single Line Diagram Dwg. No. 70-1-0504.04-3228-002
- Gas Separation Plant No.5 Overall Single Line Diagram Dwg. No. 70-1-0204.10-3528-002

2.3 Power Generation (GTGs) and Normal Supply

2.3.1 Power generation shall be rated for the peak load demand of the entire plant as minimum, including the new facilities at power factor of 0.8 lagging. The generated power shall be available at the nominal voltage of 6.9 kV or 11 kV. 3-phase AC, 50Hz.

2.3.2 The GTG shall be connected to Switchboard at generator incomer panel. Power Transformer (if required) shall be provided to suit voltage level at distribution bus.

2.3.3 The gas turbine generator shall be loaded as required for the Gas Separation Plant operating conditions and load fluctuation. The generated power possibility exported to the EGAT/PEA system (see also Paragraph 2.4 of this standard).

2.3.4 Accuracy of output voltage and frequency shall comply with the requirements specified in Paragraph 2.1 of this standard. The generators shall be capable for semi-automatic synchronization and protected by synch-check relays for continuous paralleling with the existing EGAT/PEA 22/115kV grid.

2.3.5 System design shall strongly consider capability and limits of existing installations. It shall be concerned to any necessary tie-in, modifications, extensions and additional loading by increasing short-circuit fault level, any protection co-ordination and bus voltage with large motor starting condition.

2.3.6 Current limiting reactance and/or Is Current Limiter shall be designed and installed in order to limit of increasing fault current at the switchboard, if necessary. It shall be located at the Substation for any tie to new 11kV power generation switchboards.

2.3.7 Further conditions shall be considered in accordance with the relevant sections of this standard and also specification No ES-70.02.07, Synchronous Generator.

2.4 Back-up Power Supply

2.4.1 Back-up power shall not be required when the gas turbine generators are installed, and each unit can cover the total plant load. This is due to on design basis, power generation shall be coverage total new plant load and have the capability to run as island mode.

2.4.2 EGAT/PEA grid intake shall be provided for back-up at Main Substation. The back up shall be at 22 or 115 kV. Level and the size of back-up feeder shall be covered all load demand of the Plant.

2.4.3 Power generations shall be operated in parallel with EGAT/PEA back-up. Failure of power generations or EGAT/PEA shall not effect to electricity supply.

2.4.4 All government or authority negotiation/expense and tariffs metering for the back-up feeders shall be within PTT Main Substation 115kV or 22 KV subcontractor’s scope or work/supply.

2.5 Power Supply and Distribution System

2.5.1 Principle Design Requirements

The conceptual design of the entire power supply and distribution system for the several facilities concerned shall generally comply with the basic design data and consideration as per Paragraph 2.1 above.

2.5.2 Normal and Back-up Power Supply and Distribution

The overall power and distribution system shall generally comply with the key one-line diagrams as per paragraph 2.2 above.

a) The power supply shall be made available at the substation.

b) If there have any tie-in to existing system, the existing power distribution system shall be reviewed, redesigned and relocated in order to suit new electrical equipment installation as necessary to incorporate the new facilities.

c) Power and load management system shall be provided. Load shedding automatic in case of partial or total power failure, system changeover, load transfer switching or user restarting. This shall be required for the reliable plant operation, exceptional and emergency conditions.

d) Start-up of the Gas Turbine Generators by utilizing either the EGAT/PEA-grid or normal power supply or the new standby emergency diesel generators connected to the new 400V switchboards.

e) Load transfer, without interruption from PEA power supply to the power generation after start-up of the generator.

f) Automatic start-up of emergency diesel generators in the event of a total power failure at any substation (primary or secondary) concerned.

g) Automatic restart, in case of, voltage dip for all motor loads that are operating.

2.6 Emergency Power Generation and Supplies

2.6.1 General

a) Specific requirements for emergency diesel generator (EDG) are given in specification ES.70.02.08.

b) Emergency power shall be made available as required for the safe plant shutdown of the new facilities and for black start of the plant.

c) For the various new plant facilities, the emergency power shall be derived one (1) EDG set for Substation.

d) EDG shall be installed within the new substation building area.

e) EDG shall be connected to new 400V EDG switchboard located inside substation and therefore distributed individual to emergency load.

f) EDG shall be designed with a power factor of 0.8 lagging and rated to meet load requirement plus a design margin of minimum 15 % for future use as follows:-
- Back-up power supply and black start of power generation
- Power demand for emergency load of the entire plant
- CCR facilities, if any.

g) The generated power shall be available at the nominal voltage of 400/230 V AC 3-phase + N + PE, 50 Hz.

h) Accuracy of output voltage and frequency shall comply with the requirements specified in Paragraph 2.1 of this specification.

i) The diesel generator shall be quick-start type. Automatic start-up of diesel generators shall be initiated in the event of total failure of normal and back-up power supply at the 400/230-V power buses inside substation.

j) The diesel generator shall be capable of automatic and semi-automatic synchronization paralleling with the 400/230-V normal and back-up system.

k) The diesel generator shall have the capability to do the function without load interruption as follows:-
- Manual start,
- Manual and automatic synchronization,
- Load transfer from normal power to emergency generator power and backwards
- Parallel operation between emergency generator power and normal power

l) Emergency power shall be available at least within 7-12 seconds after the generator starting signal has been actuated to start-up of diesel generators.

m) Emergency power users shall only be automatically started/restarted after the emergency supply is available. Adequate interlocking shall prevent the start/restart of normal users.

n) The fuel reservoir shall allow a continuous operation of diesel generator over a minimum period of 8 hours

2.6.2 For the Gas Turbine Generator Units

a) Emergency power shall be derived from a one (1) common standby diesel generators provided for automatic quick-start in case of total normal power failure as per paragraph 2.6.1 above.

b) One (1) 400/230-V feeder shall be made available in 400V switchboard from 400V EDG panel. This is required for interconnection to the 400/230 power supplied and motor control centers of the in-plant power generation unit.

c) This source and feeder shall be utilized for back-up power supply and black start of in-plant power generation.

2.6.3 For the Facilities/Substation

a) Separate Set of Emergency power shall be connected to the 400/230 V switchboard via a normally open incoming breaker and fed from 400V EDG panel located inside Plant substation.
b) It shall be automatically closed and provided an interlocking function to normal supply at bus-tie (Manual/Auto transfer) after the start-up of generator is performed.

c) A manually initiated semi-automatic switching of the emergency incomer, protected by synchrocheck relay shall be available.

d) The following users shall be considered for emergency supply:-
   - Any auxiliary motors and devices required for the safe plant shutdown, e.g. for emergency oil pumps, etc.
   - Motorized valves
   - Emergency lighting
   - The UPS and DC systems specified in Paragraph 2.7 herein and the critical users supplied from these systems.

2.6.4 For the new Facilities/Substation and Control Room (CCR-if any).

a) Emergency power shall be connected to 400/230 V Power Control Centre via a normally open incoming breaker located at electrical room inside CCR area.

b) It shall be automatically closed and provided an interlocking function to normal supply at bus-tie (Manual/Auto transfer) after the start-up of generator is performed.

c) A manually initiated semi-automatic switching of the emergency incomer, protected by synchrocheck relay shall be available.

d) The following users shall be considered for emergency supply:

   - HVAC

   - Lighting at Operation room, Electrical MCC room, Emergency control room, etc.

   - Fire alarm system

   - The UPS and DC systems specified in Paragraph 2.7 herein and the critical users supplied from these systems.

2.7 Uninterruptible Power Supplies (UPS)

2.7.1 Specific requirements for UPS are given in Engineering standard ES.70.02.06.

UPS systems shall be provided for all critical and sensitive users of the new facilities, i.e. PTT Central Substation, CCR (if any) and Ethane Separation Plant, as follows:-

a) Distributed control system (DCS) within the central control room (CCR)

b) Any programmable logic controllers (PLC's) either in the instrumentation, electrical or telecom systems.

c) Emergency shut-down system (ESD)

d) Load and power management system of power generation unit

e) Control protection and supervisory circuits of the required 115 kV, 33 kV, 22 kV, 11 kV, 0.4 kV switchgear and power control centre units.

f) Control protection and supervisory circuits of the 400/230 V main incomers and bus ties of any Motor Control Centre (MCC) required.

g) Any critical instrumentation required for DCS, ESD, SCADA, PIS, Tank gauging etc.

h) CO2 panel fire detection and fire alarm system.

i) Gas detection system and manual call point located inside/outside substation.

j) Telecommunication systems, whenever required

k) Shutoff Valve, Water deluge valve, whenever required.

2.7.2 UPS systems shall be provided with the following output ratings:

a) 125 V DC ± 2 % isolated pole

b) 24 V DC ± 2 %, one pole grounded which polarity is grounded

c) 220 V AC ± 2 %, ± 0.5 Hz phase-to-neutral, 50 Hz

d) AC/DC THD 0.5%

User voltages shall be considered in accordance with Paragraph 2.1 of this specification.

2.7.3 UPS systems, including sub-distribution board, shall be utilized/installed for the new facilities in the following locations:

2.7.3.1 Substation and Power Generation Unit

~~At least three (3) UPS systems shall be installed within the unit substation:~~

i) A paralleled UPS system rated at 24 V DC for generator control, power management system and Instrument System with two (2) rectifier/charger sets and two (2) battery banks for a 0.5 hour back up.

ii) A parallel-redundant or paralleled UPS system rated at 125 V DC or 24 VDC for switchgear control and generator utilities with two (2) rectifier/charger sets and one (1) battery bank for a 0.5-hour back up.

iii) A dual 2x100% UPS system rated at 220 V AC for generator control, power management system and Instrument System, with two (2) inverter sets with integrated charger and high speed, solid-state by-pass, and two (2) battery banks for a 0.5-hour back up.

iv) A paralleled UPS system rated at 220 VAC or 24 VDC for Fire Alarm System and Fire Fighting System with two (2) inverter sets with integrated charger and high speed, solid-state by-pass or two (2) rectifier/charger set and two (2) battery banks for a 4.0-hour back up time.

Note:

- 125Vdc UPS Battery back-up time shall be checked with special procedure regard to lube oil pump availability for gas turbine.
- 220Vac & 24Vdc power supply for generator unit control panel (UCP) and Power Management System (PMS) shall be taken from relevant UPS at power generation unit.
- A full rectifier/charger as well as inverter paralleled shall be available at any UPS systems specified above.
- All the above systems shall be capable for maximum power demand and a surplus of minimum 20 % with spare circuit breaker availability for future use.
- Each branch distribution circuit breaker of UPS/Charger output load shall be provide with earth leakage current detector to monitor value of leakage current (mA.)
- All the UPS systems shall be installed in an air-conditioned room.

2.7.3.2 Not Used

2.7.3.3 Not Used

2.8 Reactive Power Compensation

2.8.1 Specific requirements for Power capacitor are given in specification ES.70.02.05.

2.8.2 Reactive power compensation shall optionally be provided for the back-up supply from the 22kV and 115 kV grid by improving the natural load power factor to minimum 0.9 lagging.

2.8.3 Installing step-controlled capacitor units at the main power bus section as required for the 11.5kV, 11 kV, 6.9kV and the 400/230V system shall be capable for PF improvement. The units shall be PF-controlled as necessary due to fluctuate of system load.

2.9 Control and Supervisory Systems

2.9.1 General

The attached key one-line diagram as per paragraph 2.2.1 above shall generally apply for required extensions and modifications of overall power supply and distribution system.

Control and supervisory tasks shall be designed to incorporate the following operational functions:

a) Automatic/manually transfer function (ATS) shall be provided for normally open (N/O) bus-tie and switchboard incomer, where specified in drawings and specification.

b) Interlocking function of emergency power feeder from EDG with ATS as above item g shall also be provided where specified.

2.9.2 Control and Supervisory System of switchboard at Rayong Gas Separation Plant Complex Area

2.9.2.1 Application Functions

The system shall provide and perform the following operational functions:

a) Automatic transfer switching for both incomer and bus tie (normally open scheme) for switchboard 400VAC, 6.9kV, 11kV, 33kV distribution at ~~PTT central~~ substation.

b) Switching of bus-tie for 400VAC, 6.9kV, 11kV, 33kV switchboard, which is in normally opened (N/O), shall be possible in manually and automatically.

c) Automatic and semi-automatic start-up of the standby emergency diesel generator at substation when power failure is activated.

d) Automatic and semi-automatic switching of 400/230-V EDG switchboard feeders for normal and emergency power supply at incoming and outgoing circuits. It shall then energize to 400VAC switchboard for PG system and 400VAC switchboard for substation respectively with or without paralleling to power supplies.

e) Automatic load shedding and restart/start during transfer switching due to partial power failures at the 400-V level.

f) Automatic load shedding during total failure of normal and back-up power supply and automatic restart/start of emergency loads after the emergency supply is available.

g) Operational co-ordination and sequencing of the above-mentioned functions as required for the entire system operation.

h) Reacceleration of all motor loads after voltage dip.

The conceptual design shall be considered with the provisions specified below for the several system components.

2.9.2.2 22-kVGenerator Incomer of PTT central substation switchboard

a) Loading of the power generation

i) Each unit of power generation is running and ready for loading once voltage and frequency within limitation. It shall be indicated via annunciator “Generator Ready for Loading” for generator.

ii) Switch over the mode-of-operation selector switch into the position “Generator Supply ON”. It shall actuate the check of synchronism via synchrocheck relay to check voltage, phase angle and frequency criteria. And send command signal to generator control panel to adjust and match-up the generator voltage to the EGAT/PEA

iii) Ready conditions shall be indicated via annunciator “GTG—1 System Synchronized”.

iv) Press the push-button “Generator Incomer ON” initiating the following:

- Automatic closing of generation incoming breaker of Main PG bus which shall be protected by synchrocheck relay.

b) Island of power generation

i) Each power generation is running and loaded, which is indicated via annunciator "Generator Run" and "Generator Incomer ON".

ii) In case of PEA Grid system fail with any reason such as under/over frequency or under/over voltage by protection relay, automatic load transfer to power generation units shall available. Load shedding system shall be provided according to prevent generator overload.

c) Total failure of power generation

Generator fails by any reason. This shall initiate the following operational functions:

i) Automatic trip generator incomer breaker at PG main bus.

ii) Automatic load shedding at any connected load as per Load Shedding priority step (to verify during details design by Contractor) by PMS systems

iii) Each power generation units to be continuously synchronized to the 22kV back-up supply.

iv) Taking into account all necessary safety tasks shall suitably protect all functions referred to above by reliable protection.

v) Operation and fault status shall be visible at the related control & supervisory (human machine interface) annunciators as stipulated herein.

vi) Uninterrupted load transfer from the PEA grid supply to the power generation or parallel operation as necessary.

vii) Each power generation is running and loaded, which is indicated via annunciator "Generator Ready for Loading".

viii) Switch over the mode-of-operation selector switch into the position "Load Transfer to Power Generation". It shall actuate the synchronization of each power generation with the grid supply to be automatically performed and indicated via annunciator "PEA System Synchronized".

ix) Press the push-button “System Paralleling”, initiating the automatic closing of one PEA incoming breakers of main PG bus. It shall be protected by synchrocheck relay and indicated via annunciator “Generator Incomer ON”.

x) Islanding operation or paralleling operation as per step of operation in paragraph a), b), c), d) and e) above.

d) Black start of power generation unit

Power for this operation shall be derived from the 400/230-V system of substation from either the back-up supply system or the standby diesel generators. The following operational tasks shall apply:

i) Check availability of 400/230-V back-up at the annunciator “400/230-V Back-up Supply Ready”

ii) Automatic closing and energizing of the 400/230-V branch feeder at 400V for PG utilities bus in the new substation. It shall be indicated via annunciator “400/230-V Branch Feeder Energized”

iii) If no back-up power should be available, thus automatic start-up of diesel generator shall be actuated.

iv) Check the availability of “400/230-V DG Supply Ready”.

v) Automatic initiate similar functions as described under a) above.

vi) After successful, start-up of the power generator and synchronization of generator supply with the back-up supply, momentary paralleling of both systems for uninterrupted load transfer shall manually perform a system changeover.

vii) Further tasks shall be similarly considered to subparagraph a) to f) above.

Note: All control and supervisory tasks described above shall be locally handled at the power generator facility.

e) Emergency power supply for utilities of power generation unit

i) A total failure of power generation units and supply shall initiate the automatic start-up of standby diesel generators. As refer to under subparagraph g) above, it shall be followed by the automatic energizing of the 400/230-V back-up branch feeder to 400V for PG utilities bus, thus enabling the safe shutdown of power generation unit.

ii) Emergency power shall be available as long as required from the diesel generator sets.

iii) Further tasks shall be similarly considered to subparagraph f) and g) above

2.9.3 Control and Supervisory System of the new Ethane Separation Plant and CCR Facilities.

2.9.3.1 11kV Incomers and Bus Tie of the 11kV Plant distribution bus

a. Normal Operating Conditions with Double Radial In-Feed

i. Both the 11kV incomers shall be manually on/off switched with the incoming breakers normally closed and continuously operated, which shall be indicated via annunciator “11kV Incomer 1 (2) ON”.

ii. The 11-kV bus tie shall be normally open, which shall be indicated via annunciator “11-kV Bus Tie OFF”, but actuated for automatic closing in the event of partial power failure keeping the mode-of-operation selector switch into the position “11-kV system Change-Over”.

b. Partial Power Failure and System Change-Over

i) One 11-kV incomer tripped by its undervoltage definite time protection (relay No 27/47).

ii) This shall initiate the automatic closing of 11-kV bus tie with a time delay adjusted in a range of 1 to 5 s, which shall be indicated via annunciator “11-kV Bus Tie ON”.

iii) The above-mentioned trip and change-over operation shall additionally be supervised and controlled for the following requirements:

- A loss of voltage at the 11-kV main bus in the primary plant substation shall not initiate the trip of the 11-kV incomers, which shall be kept in the breaker ON position.

- A short-circuit or earthfault protective trip of a 11-kV incomers, which shall be kept in its OFF position.

c. Uninterrupted Load Transfer to only one Incomer

i) Switch over the mode-of-operation selector switch into one of the positions "Load Transfer to Incomer 1" or "Load Transfer to Incomer 2", as required.

ii) Press the push-button "11-kV System Paralleling", which shall initiate the closing of 11-kV bus-tie breaker and the temporary paralleling of the 11-kV incomers, indicated via annunciator "11-kV Bus Tie ON".

iii) Automatic opening of 11–kV incomer 1 or 2, as pre-selected, with a time delay of 5 s, which shall be indicated via annunciator "11-kV Incomer 1 (see note 2) OFF".

d. Back-Switching to a Re-energized Incomer

i) Switch over the mode-of-operation selector switch into one of the positions "Back-Switching to Incomer 1" or Back-Switching to Incomer 2", as required.

ii) Press the push-button "11-kV System Paralleling", which shall initiate the closing of re-energized incoming breaker and the temporary paralleling of the 11-kV incomers, indicated via annunciator "11-kV Bus Tie ON".

Notes:

1. Operational functions shall be protected as required to safety reasons, e.g. syncrocheck, bus voltage checking, blocking of transfer switch, etc.

2. Momentary paralleling shall be protected by synchrocheck, so that changer-over switching is only possible with both incomers synchronized, and limited for a pre-set time, adjustable between 1 to 5s.

3. Any short-circuit and earthfault protective trip of a 11-kV transformer feeder shall initiate the intertrip of the related 400-V main incomer.

2.9.3.2 400-V Main Incomers and Bus Ties of 400/230V Plant distribution bus at substation

The scheme described below shall apply for all 400V normally open bus-tie of the above switchboard as details below:-

a) Normal Operating Conditions with Double Radial In-Feed

i) The 400-V incomers shall be manually on/off switched with the incoming breakers normally closed and continuously operated, which shall be indicated via annunciator "400-V Incomer 1 ON".

ii) The 400-V bus-tie shall be normally open, which shall be indicated via annunciator "400-V Bus Tie OFF", but actuated for automatic closing in the event of partial power failure keeping the mode-of-operation selector switch into the position “400-V System Change-Over”.

b) Partial Power Failure and System Change-Over

i) One 400-V incomer tripped by its undervoltage definite time protection (relay No 27/47)

ii) This shall initiate the automatic closing of 400-V bus tie with a time delay adjusted in a range of 1 to 5 s, which shall be indicated via annunciator “400-V Bus Tie ON”.

iii) The above-mentioned trip and change-over operation shall additionally be supervised and controlled for the following requirements:

- A loss of voltage at the 11-kV main bus shall not initiate the trip of the 400-V incomers, which shall be kept in the breaker ON position.

- A short circuit or earthfault protective trip of a 400-V incomer shall not initiate the automatic closing of the 400-V bus-tie breaker, which shall be kept in its OFF position.

c) Uninterrupted Load Transfer to only one Incomer

i) Switch over the mode-of-operation selector switch into one of the positions “Load Transfer to Income 1” or “Load Transfer to Incomer 2”, as required.

ii) Press the push-button “400-V System Paralleling”, which shall initiate the closing of 400 V bus tie breaker and the temporary paralleling of the 400-V incomers, indicated via annunciator “400-V Bus tie ON”.

iii) Automatic opening of 400-V incomer 1 or 2, as pre-selected, with a time delay of 5 s. It shall be indicated via annunciator “400-V Incomer 1 (see note 2) OFF”.

d) Back-Switching to a Re-energized Incomer

i) Switchover the mode-of-operation selector switch into one of the positions “Back- Switching to Incomer 1” or “Back-Switching to Incomer 2”, as required.

ii) Press the push-button “400-V System Paralleling”, Which shall initiate the closing of re-energized incoming breaker and the temporary paralleling of the 400-V incomers, indicated via annunciator “400-V Bus Tie ON”.

Notes:

1. Operational functions shall be protected as required due to safety reasons.

2. Momentary paralleling shall be protected by synchrocheck, so that changer-over switching is only possible with both incomers synchronized, and limited for a pre-set time, adjustable between 1 to 5s.

2.9.3.3 400-V Emergency Supply at Emergency Generator Power Center

a) Starting of Standby Diesel Generator

i) Any power failure in the 11-kV system shall actuate the undervoltage definite time protective trip of the related incomers (s).

ii) A total power failure in the 11-kV system following an undervoltage definite time, incomer (s) trip shall initiate the automatic start-up of the standby diesel generator. It shall be actuated by keeping the mode-of-operation selector switch in the position “Auto Start of Diesel Generator”.

iii) After the output voltage and frequency of the diesel generator are stabilized, which shall be indicated via annunciator “Emergency Generator Ready for Loading”, the 400-V emergency incoming breaker shall be automatically closed. This shall, in any case, be protected by synchrocheck relay No 25 (obviously of the total outage of normal and back-up power supply). It shall be indicated via annunciator “400-V Emergency Incomer ON”.

iv) With the 400-V incoming breaker in ON position, the 400-V bus tiebreaker in 400/230V Plant distribution bus.

b) Test Operation of Standby Diesel Generator

i) Periodical test that runs of the diesel generator set must generally be possible by paralleling with 400-V normal system and the provisions described below.

ii) Switch over the mode-of-operation selector switch into the position “Diesel Generator Test”, which shall actuate its manually initiated start-up at the local control board of the set.

iii) DG load tester (dummy load) shall provide at 50% rated generator capacity for test operation of DG in periodical test or manually.

2.9.3.4 Automatic Load Shedding and Restarting or Starting

a) General Requirements

i) Generally, user loads shall be handled in accordance with the definitions in Paragraph 2.10 herein. It shall be considered for the related operational requirements during partial or total power failure.

ii) In particular, the below listed requirements shall apply in respect to automatic load shedding and restarting or starting in the event of power failure and successful system change-over under all normal, back-up and emergency supply conditions.

iii) Electric motors shall be tripped before a system changeover will occur, if necessary, to protect the rotating equipment against excessive torque that is caused by back switching to high residual voltage in phase opposition. Those motors will be restarted automatically, except it's not safe for the operational and safety considerations.

iv) If an automatic shedding of motors will not be necessary due to operational safety conditions, motors could remain bus-connected for automatic restart after the system change over, providing the restarting voltage drop will be kept within the following limits:

- 11-kV main power bus   10 % of nominal voltage
- 400-V power busses   10 % of nominal voltage

(Under all normal, Back-up and emergency)

v) Should a sequence of restarting or starting steps be necessary to keep the voltage drops within the acceptable limits, it shall be provided as required by plant operational requirements so that the more important users shall be restarted/started earlier than others.

This shall be co-ordinated by a centralized sequence control, but not by individual restart relays at the individual motor starters and feeders.

2.9.3.5 Particular Operational Requirements

a) The attached load schedule shall principally applies for load classification in accordance with Paragraph 2.10 below, except plant operational requirements may cause any other condition.

b) Load schedule shall be considered for load shedding and restarting / starting requirement as defined above.

c) For sequencing of the automatic restart/start of users, the following priority shall govern in general as necessary.

i) First priority shall be given to users required for plant and personnel safety

ii) User required for the continuous plant run shall be considered with first or second priority and so on, as required for operational considerations.

iii) General users, HVAC systems, UPS systems with own battery back-up, etc, shall be considered for last steps of sequencing, when necessary due to system loading.

d) A continuous bus voltage check at 11 kV as well as 400 V shall lead the sequential restarting/starting of users, so that the bus voltage is fully recovered before the next load step is actuated.

e) Users that considered for manual restart/start (category NL) should be prevented from restart/start as long as the automatic restarting/starting is not performed entirely.

f) All functions specified herein above shall be governed and performed by the overall control and supervisory system, which shall prevail over any other system.

2.9.4 Systems Configuration

2.9.4.1 Application of Systems

a) The control and supervisory systems shall be positioned within substations. It shall be applied for the performance of all control and supervisory functions described above in general for any system.
b) In addition, the system shall be provided for the operational data and status, such as human machine interface (HMI) and fault annunciation as specified below.

2.9.4.2 Hardware and Software Configuration

a) System shall be completely centralized located in the new PTT CENTRAL SUBSTATION substation and Plant substation in separate system. It shall be provided with the necessary interfacing to meet all application that is required for the concerned plant unit.
b) All the required functions, including system changeover, load transfer between bus-A and bus-B, auto restart/start, historical trend, etc, shall be realized with a fully redundant PLC (Programmable Logic Controller), communication line and fully redundant power supply system.
c) Self-supervisory diagnostics shall be provided. It shall be capable for the initial application and a margin of 20 % for future use.
d) System hardware shall be arranged within the centralized control and annunciator panel board of concerned plant unit and consist of the following major components:

   i) Fully redundant PLC system, consisting of two (2) PLCs and power supplies, one operating as the master unit and the second one as the hot-back unit, both with the identical firmware and application software. Fully intelligence self diagnostic and less hardwire in lasted model of vendor product shall be provided.

   ii) I/O (input/output) and interface units.

   iii) Control switches, including the mode-of-operation selector switches, push buttons and anunciator, shall be flush-mounted types. It shall be arranged at the front side of the control and anunciator panel board.

   iv) Mimic diagram of the power supply and distribution system shall be arranged at the front side of the control and anunciator panel board. It shall be shown the overall system arrangement with its operational status, the standby diesel generator, feeders and all UPS systems.

   v) Common fault alarms, status, shall be available at the front side of the control and annunciator panel boards. It shall be provided for the signals (as minimum) as follows:

- All 33/11-kV incomers of 11kV dual redundancy bus system substation
- Each 11-kV starter, feeder and metering units
- Each 11/33-kV transformer of the power generations.
- Each 33/11-kV transformer of the substation.
- Each 11/0.4-kV transformer of the substation.
- Each 400/230-V incomer of the secondary substations.
- Each 33kV, 11kV and 400-V bus tie of the substations
- Each 400/230-V branch feeder used for interconnection in the power distribution system.
- Each UPS system either 125 V DC, 24 V DC or 220 V AC of the substation.
- Each earthing switch of all switchgear (if any)
- The interposing relays required for any signal transfer and interlocking to and from the DCS (Distributed Control System), ESD (Emergency shutdown System), etc, and between the several electrical switch boards.
- The necessary cross-wiring terminals trip for the required signal transfer, interlocking and the related interconnection wiring.

2.9.4.3 Signals Transfer to the DCS System

The following signals shall be transferred to the DCS and CCR of the PTT's Rayong complex:

a) Same operational status and common fault alarms as specified under Section 2.9.5.2

b) Run, stop and fault trip indication of each motor, motor actuator and electric resistance heater.

c) Metering outfits for kWh of all secondary substations.

d) Metering outfits for Load Current (Amps) of all motors.

The tie-in for the required interconnection wiring shall be the cross-wiring terminal strips within I/E Interface panel prior to wire to Instrument Rack Room located at the new substation.

2.9.4.4 Signal Transfer from the DCS and ESD

All interlocking signals from the DCS, ESD, etc, shall be received at the tie-in cross-wiring terminal trips within I/E Interface Panel located at the new substation.

Signals shall be transferred into the central control and annunciator panel boards and distributed there as required.

2.9.4.5 Secondary Substations

a) 400-V incomers and bus ties of the secondary substations shall be controlled similarly to the 400-V main incomers and the bus tie of the primary plant substation.

b) All control and supervisory functions for system changeover as well as load shedding and restarting shall be co-ordinated with the overall system and scheme. This shall also apply for priority during auto restart/start after a system changeover and for emergency conditions.

2.9.4.6 Interconnection of the Several Systems

a) Interconnections from a several control and supervisory systems with the power management system shall be available. This shall require for system co-ordination tasks under the conditions of system changeover, load transfer switching, load shedding and restarting /starting under all normal conditions.

b) Special care shall be given to the required co-ordination in load shedding and system reloading in case of power outages. It shall be governed by the power management system of power generation units.

c) All automatically controlled functions shall be monitored to and supervised in CCR.

d) Power generation units shall be remotely operated from CCR. Local provision shall be provided as required.

e) Where manual initiation is required for semi-automatic controls, this shall be locally to the equipment.

2.9.5 Power Management System (PMS) of Power Generation Units

Specific requirements for PMS are given in specification ES.70.02.11.

The PTT Central Substation and Power Generation Units power management system shall be used to control whole Power Generation Units including. It shall be provided the following tasks of power generations and supply system with the power system either islanded or paralleled with the EGAT/PEA 115kVgrid:

- Generator MW output and frequency control
- Generator MVar output and voltage control
- Set management for turbine generator sets
- Load shedding under certain conditions
- Alarming as required
- Auto off-loading
- Temperature compensations
- Manual derating
- Feeder reclose inhibit
- System metering
- Feeder monitoring

- LCD Monitor with touch screen control

- Power balance and optimization of all feeders down to 400V

2.9.5.1 Generator MW Output and Frequency control

Each Power Generator Unit shall control MW output stable by key in set point directly in manual mode. Details are as follows:-

a) Sensing CT's and the appropriate bus 3-phase VT signals shall monitor the load output of the power generator. The signals shall be fed into the PMS via isolating CT's and the power output derived by instantaneous multiplication. The frequency shall also be measured by using of the sensing VT signals.

b) Load-sharing system shall operate on the prime mover governor to equalize powers or ratio of powers between the turbine generator set/and the PEA grid supply and maintain the system frequency when the power generation units are islanded from the PEA grid. Set governors shall be in a suitable mode of operation to maintain transient stability.

c) Microprocessor shall be incorporated into the PMS to provide pre-set adjustable parameters to vary the gain and slug of power mismatch, thus enabling the optimization of the system response.

d) Frequency set point shall be adjustable and externally accessible to enable automatic synchronization of power systems.

e) Load-sharing system shall be available whenever the microprocessor of PMS is switched on to control the generator set and the PEA grid when selected for "Automatic" control and connected to the system PEA bus.

   In the event of generator running isolated, the PMS will recognize this by circuit breaker configuration and control the independent system accordingly.

   To enable maintenance to be carried out on a running set, it shall be possible to give a "Manual" signal in order to remove the set from PMS.

2.9.5.2 Generator MVar and Voltage control

a) Same sensing CT's, VT's and breaker auxiliaries shall be utilized as for generator MW control, introducing a 90-degree phase shift in sensing volts to monitor reactive load instead of active load. The system voltage shall be directly monitored from the sensing VT's.

b) Reactive load sharing system shall operate on the generator AVR to equalize the reactive loads or ratio of loads between the generator set and the PEA grid maintain the system voltage when islanded from the PEA grid.

c) Microprocessor incorporated into the PMS shall provide pre-set adjustable parameters to vary the gain and slug of voltage mismatch thereby enabling the optimization of the system response.

d) Voltage set point shall be adjustable and externally accessible to enable automatic synchronization of power systems.

e) Reactive load sharing shall be operative whenever the microprocessor or PMS is switched on to control the generator set and the PEA grid when selected for "Automatic" control and connected to the system PEA bus.

f) To enable maintenance to be carried out on a running set, it shall be possible to give a "Manual" signal in order to inhibit the raise/lower signals to the set AVR.

2.9.5.3 Set Management

Set management shall be provided for tasks described below. Status of the set shall be monitored utilizing the same sensing CT's, VT's and breaker auxiliaries as the load-sharing system.

a) Duty Selection

Duty table shall take into account the turbine and generator status and manual/auto switch modes. Only when selected to "Automatic" operation, the set shall be controlled by the set management system. When selected to "Manual", the set shall be ignored in the duty table.

Availability of the set for starting shall also be monitored.

The set shall be provided with an independent synchronizer for initiation of correct breaker closure.

b) Set Start

PMS as required shall govern starting sequence for synchronizing and load of generator set. This shall also include a minimum load condition required for stable operation as well as correction of initial drops in output by governor raise signals.

c) Set Stop

In the event of an automatic stop request from the generator keyboard or set management, the machine shall be gradually off-loaded to a predefined load, as required, the generator circuit breaker tripped and stop signal monitored as necessary.

d) Parallel Operation with the PEA Grid

When operating in parallel with the grid, the above criteria shall be modified to account for the grid capacity and the selected target power level of the incomer (s).

e) Island Operation from the PEA Grid

When operating in island mode from the grid, the above criteria in item 2 and 3 shall be modified to account for the power generation capacity and the selected target power level of the generator incomer (s).

2.9.5.4 Load Shedding

PMS shall be capable of tripping monitored or non-monitored loads when necessary to avert cascade failure of the generation system.

Load shedding shall occur when failure of the generator results in a system overload, when an underfrequency condition is detected, or after the system load has increased to give an overload.

Shedding sequence table via priority matrix shall define the sequence of load shedding.

a) Signals Used for Load Shedding

For load shedding, the capacity of system is to be calculated using the generator maximum capacity when in automatic control.

Load output of generator shall be monitored using the same CT's, VT's and circuit breaker auxiliaries as for power-sharing system.

It shall be possible to adjust the generator maximum capacity in accordance with the monitored parameters to compensate for ambient conditions effecting generator output.

The PMS shall monitor signals from power transducers fitted to the load feeders as required. This shall allow the PMS to shed only the optimum number of load feeders as necessary to avert a cascade failure.

b) Fast Acting Load Shedding

Fast acting load shedding shall be provided in order to improve reliability in system operation.

Accordingly, trip signals shall be issued in less than 40 ms provided the trip signal is direct, i.e. hard-wired, and not via serial communication link.

The generator and the PEA grid circuit breakers shall be continually monitored.

In the event of loss of a capacity due to a fault, the PMS shall immediately calculate the new capacity of the system, and compare this with the load on the system.

If there will be a capacity shortfall, then the PMS shall trip sufficient load feeders to remove the overload based on the monitored or pre-assigned values of load.

In the event of further trips being required, these shall be initiated after an onsite adjustable pre-set delay (load shed re-trip time delay).

c) Underfrequency Load Shedding

Load shedding shall be initiated in the event of sustained underfrequency due to the inability of the prime mover to deliver the rated output.

An underfrequency shed point and an underfrequency trip time delay shall be incorporated within the PMS, with the parameters adjustable as required.

If the frequency of the system drops below the pre-set limit for a period of time equal to the underfrequency trip time delay, then the underfrequency load shedding shall be initiated.

In this condition, the feeder selected to a priority shall be shed sequentially with a time delay between each step to allow the frequency to recover.

Second stage underfrequency load shedding feature shall, when necessary, be implemented to act very quickly, if a large drop in frequency is detected, to shed a block of load in an effort to recover to nominal frequency.

d) Gradual Overload Shedding

If an overload appears on the system, then an integrating counter shall be started, with the count rate proportional to the magnitude to the magnitude of the overload.

If the overload is maintained for a time such that the counter expires, then load shedding shall be initiated as necessary to restore the remaining load equal to or below the capacity available at that time.

In the event of further trips being required, this shall be initiated after an onsite adjustable pre-set delay.

2.9.5.5 Alarms

Alarms shall be associated into the PMS as required for reliable system operation along with the necessary diagnostic alarms in accordance with the following philosophy:

a) Pre-fault alarms to recognize any critical situation at the soonest to take necessary actions.

b) Fault alarms to observe strictly the kind and source of a fault.

c) Critical alarms, e.g. to observe that a pre-set critical load level is obtained, etc.

d) Excessive capacity alarms to observe that a pre-set excessive capacity level is obtained, etc.

2.9.5.6 Auto Off-Loading

On receipt of an individual signal a set, it shall be gradually off-loaded of its MW and MVar output as required to shut down a set for maintenance purposes, etc.

2.9.5.7 Temperature Compensation

The PMS shall be utilized to modify the prime mover capability that is based on specified parameters of temperature against a derating characteristic.

The resultant capability shall be used within load sharing, grid control and load shedding software to optimize utilization of the facility and minimize load shedding without incurring overload.

2.9.5.8 Manual Derating

Facility shall be incorporated to unable the operation to derate the prime mover capability from its base rating to compensate for mechanical wear or desired operating criteria.

2.9.5.9 Feeder Reclose Inhibit

Following a load shedding sequence, it shall be re-accelerated or reconnected the plant users as the system capacity recovers.

Sequence shall be the reverse of the load shedding. It shall reconnect or permit load reconnection when the reserve is sufficient capacity to restart the respective loads.

2.9.5.10 System Metering

It shall be able to display all monitored and calculated power flows associated with controlled power system as shown by the applicable system one-line diagram(s).

2.9.5.11 Feeder Monitoring

Active power of feeders, assigned to load shedding, shall be monitored to minimize the load shedding in the event of sudden loss of capacity.

Other feeders, parameter and values shall be monitored as required for reliable plant operation at the most practical extent.

2.9.5.12 Not Used

2.9.5.13 General Control and Supervisory Scheme

a) It shall be able to operate the turbine generator sets locally as well as remotely from the new PTT CENTRAL SUBSTATION the new ESP and GSP6 CCR at Rayong GAS SEPARATION PLANT Complex area with the preference for the remote control.
b) Due to the above, all necessary control and supervisory facilities shall be available at both locations.

2.10 Load Status and Operation Duty

2.10.1 Electric loads shall be classified in load categories and considered, depending on their required reliability, as determined below.

2.10.2 The loads shall be classified areaways as follows and initially considered as indicated in the attached Electrical Load Schedule, that shall be rechecked and verified by CONTRACTOR.

a) Normal Loads (NL)

These are all loads, which need a normal power supply, automatic restart after momentary voltage dips (except some operation and safety considered not safe to restart) and power failures but no emergency supply.

b) Essential Loads (EL)

These are all loads, which are essential for the stable operation of the area facilities, connected to the normal power supply, required for automatic restart after momentary voltage dips and power failures in order to prevent shut-downs, but not needing an emergency supply.

Their status shall be defined by indication of the required duration; they have to be automatically restarted after momentary failures or voltage dips. The sequential restart shall be provided either individually or in-groups, depending of the max allowable step load for a system.

c) Critical Loads (CL)

These are all loads causing an immediate shutdown in case of their failure, e.g. instrument and control facilities.

Such loads shall be supplied from uninterruptible power (UPS) system only, due to their reliable operation.

d) Emergency Loads (EML)

These are all loads required for the safe plant shutdown, black start of PG such as auxiliary motors, which shall be possible to start from EDG.

They shall normally be supplied from the normal power supply. In case of total normal power failure, they shall be supplied from an emergency power system and restarted automatically after the emergency power is available.

Their status shall be defined by indication of the required duration; they have to be automatically restarted. The emergency restart shall be provided either individually or in-groups depending of the maximum allowable step load for a system.

2.10.3 Normal loads (NL) shall preferably be operated similar to essential loads for automatic restarting following a partial or total power failure.

2.10.4 The operation duty of any loads shall be considered as required for plant operation and indicated initially in the attached Electric Load Schedule. Contractor to recheck and verify when necessary, due to any operational requirements.

2.10.5 In addition to the above, the following definitions shall apply for the determination of system loading conditions and the corresponding power demand.

a) Normal Running Load

The load required for the continuous plant operation under normal conditions.

b) Peak Load

The maximum load required for any phase of plant operation. It shall include the intermittent operated loads, e.g. product loading pumps, etc.

2.10.6 All design and performance of the electrical power system shall comply with the requirements specified in this specification. CONTRACTOR shall responsible to recheck and verify in order to meet the operational and design requirements.

2.11 Protective Relaying

2.11.1 Short-Circuit and Overcurrent Protection

a) This protective system shall ensure selective fault trip and include therefore all power voltage levels and protective equipment. In case of tie to existing equipment, directional over-current protection shall be provided, if necessary. This is to ensure that its equipment rating will not be exceeding when connected with new plant.

b) Circuit breaker shall isolate all line and neutral.

c) Relay back up shall be provided in general.

d) The system shall be optimized and co-ordinated regarding to shortest possible trip delay, but safe selective features.

2.11.2 Earth Fault Protection

a) This protective system shall ensure selective fault trip and include therefore all power voltage levels and protective equipment.

b) Relay back up shall be provided in general.

c) All lighting panel and receptacle circuits shall be equipped with earthfault protection.

d) Sensitivity of protective relays shall ensure their safe operation. The degree of protection for electrical machines and transformers shall cover in minimum 90 % of windings.

e) The system shall be optimized and co-ordinated regarding to shortest possible trip delay, but safe selective features.

f) Earth fault protection shall be provided with ZCT, Ring CT or Toroidal CT for all applications

2.11.3 Overload Protection

All equipment shall be safety protected against overload by adequate secondary relaying or primary devices, which shall be selected with consideration of the thermal characteristics of equipment.

2.11.4 Undervoltage Protection

The protective system shall have the following features:

a) Winker failures up to 600 ms caused by faults in the grid shall not affect any feeder trip or transfer switching in the normal power system.

b) Short-time voltage drops up to 20 % for 2 seconds shall not affect the continuous operation.

c) Residual voltage check shall be done in HV systems with automatic transfer provision. A system changeover bus tie closing shall only be possible if the bus residual voltage of the failed system has dropped by 20 %.

d) Voltage check on the remaining bus shall be done with regard to step loading conditions. It shall be proved that the bus voltage is recovered to 100 % of the service voltage before the next loading step will be switched on.

2.11.5 Other Protective Equipment

a) The attached Table No.2.11.5 shows the protective equipment, which shall be provided as a minimum in HV systems.

b) Sensitivity and grading of protective relaying shall satisfy the conditions to be considered specifically.

Table 2.11.5 Protective Measures and Relay Application

Protective of Equipment or Feeder	**Protection**	**Application**
1. Generator	Undervoltage	Protection against undervoltage
	Overvoltage	Protection against overvoltage
	Reverse power	Protection against motoring
	Loss of Excitation	Protection against loss of excitation
	Current Unbalance	Protection against unbalance current
	Thermal over current	Protection against thermal over current (RTD)
	Time Overcurrent (Ground)	Neutral Ground Overcurrent Relay
	Time Overcurrent (Voltage Control)	Protection against time overcurrent (Voltage Control)
	Frequency	Protection against over/under frequency
	Lockout	Lockout Auxiliary
	Differential	Generator Differential
	Rotor earth fault	For machines above 7.5 MVA
	Directional	If necessary for generator interconnect
	Field failure	Detecting reducing of field below machine stability limit
	Negative phase Sequence	Protection against rotor heating due to unbalanced load
	Neutral displacement	Definite time delay

	Rotating diode failure Synchrocheck Fuse failure	For brushless type machines For generator paralleling with any other source For metering circuit and protection circuit
2. Transformer	Differential Overcurrent Earth fault Buchholz Pressure Relief Winding temperature Oil temperature Oil Level Detector for Diaphragm Check Lockout	For transformers above 3.5 MVA Inverse time overcurrent Inverse time overcurrent, resistor (if any) to include in protection/ restricted earth faults Long time delay for back-up protection of earthing resistor Protection against incipient faults Lockout Auxiliary
3. Incoming feeder	Overcurrent Instantaneous Overcurrent Earth fault Undervoltage Overvoltage Directional Reverse power	Inverse time-overcurrent, directional, if necessary Instantaneous Overcurrent Definite time overcurrent Definite time undervoltage For protection of main incomers If necessary due to interconnection

	Lockout	Lockout Auxiliary
4. Feeder	Phase overcurrent and short circuit Without ground sensor relay Time delay ground fault (50N) Instantaneous ground fault(51N) With ground sensor relay Time delay ground fault (50G) Instantaneous ground fault(51G)	Phase overcurrent and short circuit Time delay ground fault Instantaneous ground fault Time delay ground fault Instantaneous ground fault
5. Induction Motor	Undervoltage Undercurrent Current Unbalance Overload Winding Overtemperature(RTD) Locked rotor protection Instantaneous & time overcurrent Instantaneous & time overcurrent ground Differential	Definite time undervoltage Definite time undercurrent Definite time current unbalance Inverse time overcurrent Winding overtemperature (RTD) Locked rotor protection Instantaneous & time overcurrent Instantaneous & time overcurrent ground *Definite time overcurrent for 6.6,11 kV Motors (via toroidal-core current transformers/cable type CT)* For motors of 3 MW and above

	Lockout	Lockout Auxiliary
6. Synchronous motor	Undervoltage	Definite time undervoltage
	Undercurrent	Definite time undercurrent
	Current Unbalance	Definite time current unbalance
	Overload	Inverse time overcurrent
	Winding Overtemperature(RTD)	Winding overtemperature (RTD)
	Locked rotor protection	Locked rotor protection
	Instantaneous & time overcurrent	Instantaneous & time overcurrent
	Instantaneous & time overcurrent ground	Instantaneous & time overcurrent ground *Definite time overcurrent for 6.6,11 kV Motors (via toroidal-core current transformers/cable type CT)*
	Differential	For motors of 3 MW and above
	Loss of excitation	Loss of excitation
	Out of step	Out of step
	Rotating diode Failure	Rotating diode Failure
	Lockout	Lockout Auxiliary
7. Special application	Fuse failure	For fused feeders and potential transformer
	Undervoltage	For bus sections, according to requirement
	Trip supervision	If the open-circuit system is used for trip circuits
	Underfrequency	If necessary for automatic transfer circuits of incomers and bus ties

2.12 Motor Controls

2.12.1 General Design Conditions

a) All motor starters shall be grouped together within HV switchgear, LV power and motor control center to be located in substations or local switchroom in a non-hazardous area.

b) The following design shall be provided:

   i) 6.6kV or 11kVmotor starters
   Fused contactor units up to 1,800 kW, circuit breakers above 1,800 kW.

   ii) 380V starters for motors and motor actuators.
   Fuseless type contactor combination starters up to 159 kW with molded case circuit breakers.

c) Feeders for electrical heaters shall be performed similar to the motor starters.

d) Control of feeders shall be provided according to process requirements and those, specified in this standard.

e) All starters and feeders shall be provided with remote control except those for directly interlocked auxiliaries (e.g. motor anti-condensate heaters).

f) Wiring of feeder circuits shall be standardized so those feeders of same size can be interchanged. Ferules shall be used for cable connection in general.

g) Special control and interlock circuits (e.g. for automatic restarting or sequence starting or sequence starting) shall be provided outside the feeders in separate control boards.

h) Interposing relays shall be used for external interlocking and tie-in, to be installed within separate control boards with interconnection wiring to the motor and heater feeders.

i) Wherever possible, motors shall be provided with direct online full voltage starting except for special cases (e.g. two-speed drives, reversing drives).

j) Normal method of control shall be with momentary start/stop-contacts. For LV-motor feeders, this shall be done normally with the 3-wire method and maintained external stay-put STOP contact.

k) Where automatic starting for stand-by motors is provided, facilities shall be furnished to allow the designated “running” and “spare” motors to be interchanged at intervals to suit operating convenience. The “spare” and “running” selection circuit shall not inhibit the auto start function.

l) Motors starters including any reduced voltage starters and/or starting with rheostat starter of slip-ring motors shall be fully automatic in starting procedure, needing only one action by the operator to complete the starting process.

Time delayed undervoltage protection shall be fitted to motor starters for motors essential to the process. Those starters shall always be accompanied by time delayed re-acceleration relays independently adjustable in order to spread the restarting load over a period of time but according to a process requirement. It shall ensure that large motor residual voltages have decreased to acceptable limits.

In addition, motor starters shall include current, kW / kVAR and PF reading, earth fault protection, tripping recorder and motor running hours. Motor start for pump shall be provided the low current protection.

Motor starter shall be one of intelligent type motor control center with digital multi-meter, analogue ammeter, digital multi function protection relay, communication port (profi-bus or equivalent, etc.) The system must be linked all feature data to the Human Machine Interface software at Control and Supervisory (C&S) panel.

m) Careful provision shall be made to prevent capacitance effects on control wiring runs from affecting the performance of the control circuits, even to the extent of providing DC control systems, if necessary.

n) Motor run, stop and fault indication lamp (with bulb) shall be provided for all motors, with the indication signal transferred to the DCS. Indication lamp (with bulb) shall also automatically indicate motor protective trip, which shall be clearly distinguished form normal motor “RUN” or “STOP” conditions.

o) An individual starter shall be provided for each motor and motor actuator. The starters for motor actuators of motorized valves shall be full-voltage reversing type and installed within the concerned motor control center but not be combined locally with the motor actuator.

p) Where two-speed motors are furnished, consideration shall be given to the provision of automatic down shift in motor speed upon high-speed overload trip. Two speed pole-changing motors shall have speed-indicating lights located in their control station. It shall determine the speed at which the motor is running. Adequately, variable speed motors shall be provided with continuous speed indication covering the full range of speed variation.

q) Motor overload protective devices shall be installed in all phases. Earth faults must be safely tripped. Earth fault shall be detected by ZCT or ring CT.

r) Where variable speed motors are required, speed control shall be preferably accomplished by using of static type converters with thyristor or transistor control.

It shall be designed to limit their harmonics interference to acceptable values in accordance with the specification ES-70.02.20.

s) Reference signal for speed setting shall be 4 – 20 mA, and derived from DCS in general. For variable speed slip ring motors with sub-synchronous converter cascade see Standard Spec No E-70.02.20.

t) Where two machine sets are provided, one provided for the continuous run and the other one for standby, their motors shall be fed from independent power buses.

u) Where VSD or softstart unit are provided, bypass magnetic control system shall design to corporate in the unit.

2.12.2 Local Control Facilities

a) Start and Stop control shall normally be located from beside the motor. Clearly legible warning signs shall be installed adjacent to all equipment or remote started motors.

All such motors shall have beside them an additional overlapping type selector switch with Manual and Automatic (or remote) position. It shall be used to prevent the motor from running, start it manually independently from the automatic control or switch to the automatic control.

b) The local control stations shall be provided adjacent to the equipment, for which they are needed (e.g. motors, process heaters, motorised valves, etc). They shall be equipped with:

i) Control push button switches with momentary closed or opened START (RED) and STOP (GREEN) contacts with lockable in STOP position (pin type). The switch shall be provided with protection against unintentional operations.

ii) Selector switches with Manual and Automatic (remote) position

iii) Ammeters

iv) Pilot lamps for running (RED) and stopping (GREEN) status

c) The enclosure of local control stations shall not be lower than IP65 with canopy. They must be of the same explosion-proof class as the motor they control and will be explosion-proof type for hazardous areas an. Inside and outside earthing terminals must be provided for metallic parts.

d) In case a local control desk or panel board exists (e.g. for compressors), the local motor control and monitoring equipment shall be build-in into such facility.

e) Motors driving fans shall be protected by fan anti-vibration trip switches, wherever required.

f) GRP or nonmetallic material shall not be used.

2.13 Communication

2.13.1 Telephone System (PABX)

a) For specific requirements for PABX are given in specification ES-80.02.13.

b) A new telephone system shall be provided. It shall be enable for all internal traffic and some outgoing external telephone connections automatically.

The telephone system shall be connected to the existing PABX situated in the communication building of the PTT's complex at PTT's Rayong.

The telephone sets shall be equipped with keyboard.

Indoor telephone handsets shall be latest model with clock, timer, hand free or speak phone, memory, function key, calculator, etc. 10%, min one, of indoor telephone handsets shall be wireless type.

The wiring for the telephone system shall be installed in rigid hot dip galvanized steel electrical conduits. Wiring for telephone inside building shall be embedded in wall, above ceiling void or under raised floor.

Ferules or cable lugs shall be used for cable connection in general.

c) CONTRACTOR shall prepare a detailed telephone allocation drawing showing locations, types of extensions and any necessary facilities.

d) Full account shall be taken to the effects of hazardous area on telephone installations.

e) CONTRACTOR shall provide line amplifiers, if necessary, due to line length.

f) Acoustic hood (or sound proof) shall be installed for TEL & PUAS set which shall be located in gas turbine skid, refrigerant compressor, big rotating machines and the area where surround noise shall be affected to communication quality.

g) Telephone located in process area shall be equipped with ringing sound and lamp.

h) The hot line telephone shall be provided for intercommunication between Ethane Gas Separation Plant central control room and customer control room.

2.13.2 Plant Intercommunication (PUAS)

a) Specific minimum requirements for PUAS are given in specification ES-80.02.14.

b) The process, and power generation units shall be equipped with a new public address system for plant intercommunication, covering the process and/or operating area (s) served by the existing CCR. Existing public address main control panel (8 areas) shall be retrofit replace with new public address main control panel (10 areas).

c) This system will be used for operating and emergency warning purposes.

d) All vital control points, such as compressor houses, local operating points, pump stations, fire pumps and loading arm control, shall have two-way communication with the central control room of Gas Separation Plant, located in CCR.

This system shall be independent of the normal plant telephone and be suitable for the noisy environment likely outside the control room.

In special areas additional loudspeakers with remote switch-on control shall be installed to reach the staff-members concerned for normal operation and emergency calls.

e) Any call with the control room shall be indicated by visible and audible signals at the sending point.

The call shall be stored if a connection exists at that time.

Rotating reflecting lights shall be provided at noisy points, where an audible signal would not be sufficient.

Generally, the system shall be designed to suit the following mode of operation and function: -

i) Alternating two-way intercommunication between a pair of two call stations. It shall be alternately controlled a speech channel for listen and talk by pushing a key.

ii) Direct-line connection for immediate calling of desired subscriber. This is by means of separate keys for connection of a master call station to any local call station and vice versa. Signal lamps shall be available at the call stations to indicate whether a desired subscriber is free or engaged.

iii) Call storage to be activated, when desired, subscriber is engaged at the time of a call demand. It shall be indicated by flushing light on relevant call stations.

iv) Cancellation of call storage after the call is received by desired subscriber. It shall automatic reset in case the call is not received.

f) Multiple calls to all local points shall be provided to enable a simultaneous call from the control room to all local call stations.

g) The system shall be available for one hour in case of total power failure and therefore shall be powered from a 220 V AC UPS system.

h) The local call stations shall be performed with IP65 enclosure and be explosion–proof within hazardous areas.

i) Sufficient fixed loudspeakers shall be installed to cover the whole process unit area(s) without dead spots or zones of confusion of sound.

j) CONTRACTOR shall prepare detailed intercom allocation drawings showing locations and facilities to be provided on each.

k) The wiring for the PUAS system shall be installed in rigid hot dip galvanized steel electrical conduits. Wiring for telephone inside building shall be embedded in wall, above ceiling void or under raised floor.

l) Ferules or cable lugs shall be used for cable connection in general.

2.13.3 Closed-Circuit TV System (CCTV)

a) For specific requirements for CCTV are given in specification ES-80.02.15.

b) Color television cameras for supervision in process area, vital process unit, tank farm, each power generation unit, where is classified as safety & security requirement shall be provided. Moreover under construction period, when site office established, CCTV cameras and monitoring system shall be setup for safety & security requirement at entrance gate and complete around construction area. All cameras signal must be sent to PTT main security guardhouse in PTT Rayong Gas Separation plant Complex area.

c) The cameras shall be remote-controlled and motor-operated panoramic and tilting head.

d) For the flare supervision, one (1) stationary-mounted color TV camera shall be provided.

e) All cameras and the panoramic and tilting heads shall be remote-controlled from the existing central control room at Rayong Gas Separation Plant central control building.

f) Supervised areas are:
- power generator unit.

- generator control room, switchgear rooms
- Tank farm
- Flare
- Process area
- Main entrance (Guard House)

Under construction period, temporary security CCTV cameras shall be provided for monitor main site entrance and complete around construction area. All CCTV signal shall be linked to PTT main security guardhouse in PTT Rayong Gas Separation plant Complex area.

g) The flare camera shall have its own monitor located in the control room. The number of cameras shall be considered by operation and safety & security requirement.

h) The cameras shall have one common monitor with a selector switch in the common control console/matrix.

i) The Contractor shall provide new flare cameras. The monitors and the camera control consoles shall be installed in the new control room.

j) The wiring for the CCTV system shall be installed in rigid hot dip galvanized steel electrical conduits. Wiring for telephone inside building shall be embedded in wall, above ceiling void or under raised floor.

k) Ferules or cable lugs shall be used for cable connection in general.

2.13.4 Local Radio System (LORS)

a) For specific requirements for LORS are given in specification ES-80.02.17.

b) The system shall principally be configured in accordance with ES-80.02.17.The distance range of the radio system has to be sufficient for the process area, the in-plant power generation unit and the tank farm area.

The UHF frequency ranges, TX power, channel spacing and all technical data and regulations are part of the Contractor’s detail planning (see project std.ES-80.17).

CONTRACTOR is responsible for negotiations with the local authorities, as well as all charges, tests and approvals, which the local authorities may require.

2.14 Cable and Wiring

2.14.1 Cable Runs

a) Cable shall run above or below grade depending on local conditions as well as fire risks, risks by leakage or seepage of process fluids, rodent attack, mechanical and thermal damage.

b) The preference is for LV and HV cables to run in sifted sand filled concrete trenches with removable covers below grade, wherever possible.

c) Cable tray systems shall be avoids using for main routes above grade in hazardous and non-hazardous areas as much as possible.

d) When cables are placed in trenches in paved areas, the trench shall be concrete lined, sifted sand filled, with removable cover.

e) HV and LV cables and communication cables shall be laid separately in the cable trench or tray system for minimum interference with each other.

   In case of unavailable space to keep between each type of cables, Contractor shall be responsible to provide the separators and keep lower spacing in accordance with specific standard included in this specification.

f) Individual cable runs from the main routes to the equipment have to be brought and provided through conduits.

   Rigid hot dipped galvanized steel conduits shall be used for this purpose.

   In areas subject to corrosion and cable feeder from lower to higher location that are difficult to replace, rigid hot dip galvanized steel conduit with PE coating shall be used.

   Above grade, conduit ends shall be sealed with a suitable compound.

g) Cable trenches shall be carefully sealed against liquids and gases where they leave hazardous areas or enter control rooms or substations.

h) Overhead cable runs supported on trays or racks or clamped on flat surfaces shall be armored and suitably protected against mechanical damage. It shall not be run over hot locations or places subject to undue fire risk.

i) Cable trenches and trays shall be sized to allow additional future cables. The certain cables shall be kept segregated from others (e.g. control cabling any heavy power cables, high voltage and instrumentation cables).

   Further to the above, provision must be made in cable trenches and overhead runs for at least 30 % spare capacity.

j) All cables from basement of substation entries to equipment in substations shall be from underground or side of the building, and never from the roof.

k) Unnecessary crossings or “knitting” of cables shall be avoided, and cables shall be installed neatly and clipped into place to permit easy tracing.

l) All unused opening of any holes shall be securely sealed with fire retardant materials with minimum 2 hours type withstand. It is required to prevent fire, leakage of rainwater and hazardous atmospheres into the building.

2.14.2 Cable Types and Sizing

a) The cable types to use for power, control, lighting, and communication shall be selected in accordance to IEC 60502.

b) The following cable types shall be used for the following applications:

- For field installations within the gas plant, tank farm and jetty area, including line feeders.

  - HV cable shall be 3-core copper conductor type, XLPE-insulated, steel wire armoured and overall PVC-sheathed and rated at min 6 /10(12)kV or 8.7 /15(17.5) kV or 18/30 (36) kV.

  - LV power cable shall be 4-core copper conductor type, XLPE-insulated, steel wire armoured and overall PVC-sheathed, and rated at 0.6/1 kV.

  - Control cable shall be multi-core conductor type, XLPE-insulated, steel wire armoured and overall PVC sheathed, and rated at 0.6/1 kV.

    Control cable shall have at least 20% spares of number of cores.

  - LV cable for lighting and socket outlets shall be 4- or 5-core copper conductor type, XLPE-insulated, steel wire armoured and overall PVC-sheathed, and rated at 0.6/1 kV.

- For installations similar to those under i but within substation (s) and switchrooms indoor.

  - Same types as specified under item i, except lighting and socket outlets indoor shall be XLPE-insulated, steel wire armoured and overall PVC-sheathed, and rated at 0.6/1 kV.

- Telephone system (PABX)

  - Telephone installation outdoors

Solid copper wire 0.8 mm diameter, PVC- or PE-insulated, 4-wire-twisted, screened, steel wire armoured and overall PVC sheathed, with 100 % and minimum of one 4-wire-twisted spare capacity

- Telephone installation indoors

  Solid copper wire 0.6 mm diameter, PVC- or PE-insulated, 4-wire-twisted, screened and overall PVC-sheathed, with 20 % and minimum of one 4-wire-twisted spare capacity.

- Plant intercommunication (PUAS)

  - Outdoor calls stations
    Solid copper wire 0.8 mm diameter, PVC- or PE-insulated, 2-wire-twisted, screened, steel wire armoured and overall PVC-sheathed, with 40 % and minimum of one 2-wire-twisted pair spare capacity.

  - Indoor calls stations

    Multi-core solid copper wire 0.6 mm diameter, PVC- or PE-insulated, twisted pair, screened and overall PVC-sheathed

- Loudspeaker connections outdoors and indoors

  - Main cable

    Solid copper wire 2.5 sqmm, PVC-insulated, steel wire armoured, when installed outdoors, and overall PVC-sheathed, rated at min 600 V, with 40 % and minimum of one pair of cable available for spare capacity.

  - Connection cable outdoors and indoors

    Same type as for main cable, but 3-core solid copper wire 1.5 sqmm, non-armoured, with 20 % and minimum of two pair of cable available for spare capacity.

- Closed circuit television (CCTV)

  - Depending on the system requirements, wide band transmission cable ~~coaxial type,~~ fiber optic cable ~~single mode~~ with 100 % spare capacity

  - Outdoor CCTV cable shall be armour cable

- Radio systems (SCRS, LORS)

- Antenna cable suitable for the stationary-mounted station, if any, within the main control room.

- Fire detection and alarm systems

  - Main cables outdoors

    Stranded copper wire size 1 sqmm, Fire resistance PVC-insulated to IEC 332-3, twisted pair, screened, steel wire armoured and overall PVC-sheathed, with 40 % spare capacity.

  - Cable indoors
    Same type as for main cable outdoor with 20 % spare capacity

Note:

"Indoors" in this case means the installation within the control room building and the substation buildings only.

c) Concealed wiring for general purposes such as in buildings shall consist of individually insulated conductors in rigid hot dipped galvanized steel conduits.

In areas subject to corrosion, rigid hot dipped galvanized steel conduits with PE coating shall be used in place of steel.

d) Cables and conductors shall be sized based on the current carrying capacity, voltage drop consideration and short-circuit rating as follows:

i) Current carrying capacity

Cables shall be rated in accordance with Electrical Research Association Report No. 69-30 or IEC 60502.

ii) Voltage drop shall be limited under full-load conditions for

Feeders and sub-feeders	1 %
Motor branch circuits	3 %
Lighting branch circuits	3 %

Additionally, cables shall be so sized as to ensure that motors are not overloaded or prevented from starting by voltage drop.

iii) Short-circuit rating of cables shall be selected for breaking capacity of switchgear to which the cable will be connected.

e) Control cable shall be selected by consideration of capacitance effects to be safety prevented in control circuits.

f) Control cable shall be selected by consideration of capacitance effects to be safety prevented in control circuits

g) Wire and cable material shall conform to approved specifications as following

- Vermin proof/Anti-Termite/UV Protection/Flame Retardant and shall be impervious to moisture, vermin, insects and fungi and shall be suitable for tropical service and sun ray effects when laid on open-air trays.

h) The overall jacket of the cable shall be resistant to vermin by special chemical treated polyvinyl chloride (PVC) compound.

i) All cables shall be adequately protected to prevent moisture pick up at all times during shipment, installation and operation.

j) Details of the cables such as type, voltage, sizing, core etc. shall be printed on the outer insulation.

2.14.3 Wiring

a) Cables of similar appearance but differing characteristics (such as PVC and XLPE insulation) shall be clearly distinguishable both before and after erection without opening for inspection.

b) Cable glands shall be generally used for installation of all cables, power cables, control cables, communication cables, fire alarm cables, etc. Cable glands shall be used at both sides of each cable. Cable glands of all types shall be suitable for cable fixing as well as sealing of cable entries.

c) Every cable and cable core on the design drawings and plant shall be identified with a tag number.

This cable and wire identification number shall appear at each end of very cable and wire and the cable number at points along the run where it changes route or mixes with other cable, entering or leaving the route.

Every control circuit (whether for instruments, alternator motors or protective systems) shall be provided with a schematic wiring diagram and a detail wiring (point to point) diagram.

Each wire and terminal shall be numbered.

All provided equipment shall have wiring ferules indicating the number of the wire at each end and beside each terminal.

All wiring for main and control circuits on all equipment shall be brought out to number terminal strips. It shall be given unnecessary to carry field wiring into the equipment internals.

d) Each cable (excepting individual branch circuit lighting cables) shall be identified at each end and the point where a main route will be leave with a stainless steel tag firmly attached by stainless steel strip.

Additional identification tags shall be provided in distances of max 10 m. for cable runs in underground and sand filled concrete trenches.

Cable tags shall be completely prepared before starting cable pulling of each cable.

Stamped lead or stainless steel discs are required.

Plastic tags are not acceptable for cable numbering, but may be used for core numbering.

e) All cable jointing and terminations shall be solderless compression type. Cable running shall be carried out to minimize (or eliminate where possible) joints in the run of a cable.

f) All cables for building, means lighting cable, receptacle cables, telephone cables, PUAS & intercom cables, fire alarm / fire fighting cables, LAN cables, etc. , shall be run in concealed conduit in wall for vertical direction and run in cable tray or wire ways above ceiling void or under raised floor for horizontal direction.

2.14.4 Bus Ducts

a) Bus ducts may be used for linking of transformer secondary with the associated switchgear. It practical shall be considered in technical and economical point of view.

b) They shall be metal-enclosed, IP55 protected in minimum, and be weatherproof when installed outdoors.

c) Bus bars shall be sufficiently sized and flexible adapted to the transformer bushings and switchgear buses or breaker lugs. Material shall be copper and coated with silver.

d) Overheating of bus ducts shall be safety prevented. The design shall be short-circuit-proof.

e) Installing space heaters where necessary shall prevent condensation of moisture.

f) Condensate drain valves shall be provided at the lowest parts of a bus duct line-up.

g) Earth bonding wire shall be provided for all joint or section of bus duct.

2.15 Earthing

2.15.1 General Conditions

a) Suitable earthing shall be provided:

   i) For safety of personnel

   ii) To limit the voltage on circuit when exposed to a higher voltage than that for which the circuit was designed

   iii) To limit the maximum potential to earth due to normal voltage

b) Within process and industrial areas, the overall earthing system provided shall be a grid type system, which is bonded to earth by means of grounding electrodes.

   The main grid shall be looped. Charge at any point of this grid shall have at least two paths to earth.

c) The earthing grid system shall be used as the common earth for all purposes including system neutrals (via separate connection), electrical equipment enclosures (power earthing), major structures (lighting earthing) and machinery/ apparatus (static earthing).

d) Additional earthing systems only are provided when specifically required (e.g. high-qualified computer earthing, etc) under consideration of such special conditions.

e) All earthing systems shall be of fully adequate size to cope with the conditions imposed with suitable provision against corrosion of the components, including all underground and above ground connections.

f) The main ring conductor size shall be at least 70 mm2 copper cross-sectional area.

g) The individual loop conductors at least 25 mm2 copper cross sectional area.

h) Copper conductors shall be PVC sheathed for corrosion protection.

i) Cadweld type earth connectors shall be used for the earth wire joints in general.

j) Grounding electrodes shall be connected together and to earth grid in an equalizing box located above ground. Each group of grounding electrodes shall have resistance to earth less than 10 ohm before connected to earth grid. After bonding all equalizing boxes to earth grid, every point on earth grid shall enable earthing equipment to have a resistance to earth of not more than 2 ohm.

k) Cable tags shall also be provided for earth cable at equalizing boxes.

2.15.2 Equipment Earthing

a) Branch earth buses shall connect the equipment to the main grid system. Long Branch earth buses shall be looped and connected to the main grid at least at two points.

b) Major steel structures, process columns, vessels and stacks shall be protected against lightning strikes by direct earthing at their bases.

c) Large steel structures, including building frames, shall be connected to the grid earthing system at two or more widely separated pints.

d) The metal framework of all structures and buildings housing or supporting electrical power equipment shall be earthed.

e) All metallic cable conduits, cable armor and any lead sheaths shall be earthed.

f) Swivel or insulated pipe joints have to be provided with bonding jumpers to ensure electrical continuity.

g) The transformer and switchyard fences and gates shall be earthed at the posts and connected to the main earthing grid.

h) Equipment and structures such as area lighting poles, metering sheds, fences, posts, etc, installed in remote offsite locations shall be earthed by driving individual earth rods

2.15.3 Electrical Equipment Earthing

a) Non-current carrying metal parts including metallic conduit and enclosures of electrical equipment shall be bonded to the earthing system.

b) Switchgear and motor control centers shall be provided with an earth bus, which is bonded to the enclosure.

Individual feeder cables shall be earthed by connecting to this bus via grounding core within the same cable. In turn, it shall be earthed by connecting to the main earthing grid.

c) All motors shall be earthed by connecting to the main earthing grid.

d) Individually mounted LV-equipment, e.g. motors, local control stations, lighting fixtures, and receptacles shall be earthed inside the enclosure.

e) The frame shall be earthed inside the enclosure. The frame shall be earthed by connecting to the main grid.

f) Surge protection or suppressor shall be provided for sensitive equipment, such as PLC, Control card, electronic cards etc.

2.15.4 Electrical System Earthing (refer to **Earthing Principle Connection Diagram)**

a) Electrical system earthing shall be provided in accordance with the requirements of the power and distribution system design.
Resistance to earth of each ground loop value shall be less than 2 Ohms before connect to other ground loop via equalizing box.

b) Transformer and other system neutrals shall be connected to the electrical earthing system in an appropriate way. This is to ensure continuous and fixed reference for the system.

c) Electrical earth system shall be designed to provide an ample path for earth fault currents and also to serve for earth fault relaying.

2.15.5 Lightning and Surge Protection

a) Generally, structural steel, vessels and tanks shall be considered adequately protected against lightning, being electrically continuous through the equipment earthing system and properly bonded.

b) High mast or poles with air terminal shall be installed in tank area. It will be provided as the lightning strike point of the area instead of lighting rods on the high structure.

c) Additional lightning protection shall be provided only when specifically required by the geographical location, from the point of view of frequency or severity of thunder storms, possible hazards due to the flammability of materials handled or when deemed mandatory by applicable codes and regulations.

d) In such cases lightning protection shall be provided in compliance with IEC 61024 or equivalent.

e) Switchyards and substation will be protected against lightning by means of lightning arresters and surge capacitors.

f) All incoming overhead lines shall be provided with such protection on the line side.

2.15.6 Static Control Earthing

Static control will generally be achieved through proper bonding and earthing as provided by the equipment earthing system.

a) Where additional static control and elimination is required due to nature of the process and the explosive properties of the materials processed, provisions shall be made for this purpose accordingly.

b) When required, static earth detection system with visual and audible alarms shall be furnished in areas where static electricity may cause explosions.

2.15.7 Instrumentation System Earthing

Three (3) sets of earth connection for instrumentation shall be provided as follows:

a) Computer earth for DCS system with resistance to earth less than 1 Ohm.

b) Instrumentation Clean earth for shield with resistance to earth less than 1 Ohm.
c) Electrical Plant earth as refer to Paragraph 2.15.4 above.

2.16 Lighting

2.16.1 General Conditions

The plant and/or the facilities shall be adequately lighted for routine operations and maintenance. Refer to table 2.16.2.

An emergency lighting shall be provided for the strategic points to enable the plant and/or facility operation under emergency conditions when the normal lighting has been failed.

In case of an interruption in illumination, e.g. during start-up of emergency lighting is in operation.

Special lighting shall be provided for safety and indication purposes for marine facilities, aircraft warning, shower marking, etc as per the specific requirement required at any point.

Lighting design shall be provided substantially even illumination over each area of the plant and/or facility without dangerous shadows or dark patches.

It shall be taken in lighting design of the effect of voltage dips on lighting and lamps (e.g. Metal Halide and/or sodium vapor lamps), and physiological and dazzling effects.

Lighting fixture shall be Metal Halide or sodium vapor or compact fluorescent or LED and fluorescent type with incandescent type only used for special application.

Floodlights shall be as used as the primary sources of outdoor illumination and the number of local lighting fixtures minimized, wherever possible.

Metal Halide or sodium vapor lamps shall be used for floodlights and streetlights where the time interval to re-strike after voltage dips would not constitute a hazard.

All type of lighting fixtures must be metallic. GRP Plastic Fiberglass or nonmetallic lighting fixture shall not be used.

In all the other cases, fluorescent lamps shall be provided normally, preferably in case of low fixing points and confined conditions, e.g. for operation and maintenance purposes in outdoor and indoor plant and/or facility locations.

General outdoor as well as aviation obstruction lighting shall be photo-electric cell controlled to operate all the external lighting simultaneously, but allowing that certain areas (e.g. analyzer house) will be illuminated as required during the day as well as in the night. This function shall be incorporated to main lighting distribution panel in substation. The timer setting and energy recording shall also be provided.

Lighting panels shall be provided with circuit breakers for the protection and fully isolation (Line – Neutral Isolation, 2 pole Circuit Breaker) of individual circuits.

All the lighting except special ones shall be operated on the level of 220 V AC either in single or 3-phase, 5-wire circuits.

The 220 V AC circuits shall have a maximum connected load of 2,500 VA.

The fittings on the various circuits shall be interlaced.

All lighting fittings shall be adequately supported and readily accessible for lamp changing and fitting maintenance.

Process control room lighting and building lighting shall be modern design, glarefree, using instant-start fluorescent fittings.

Shadowless and reflectionless lighting of operator stations, visual display units and control panels shall be considered, whatever their angle to the observer.

All fluorescent lighting tubes shall be of “daylight” type and circuits shall be arranged to eliminate stroboscopic effects.

Silver coating reflector and electronic ballast with harmonics filter shall be used for all indoor lighting fixtures. For the other outdoor lighting fixtures, low loss ballast shall be used.

Earth fault protection shall be provided for all individual circuits.

Lighting poles installed on plat form or ladder or stair shall be well supported by a support welded to the structure.

Lighting fixtures shall be connected together or to lighting circuit in junction boxes. Lighting fixtures shall not be used as connection point in any case.

2.16.2 Lighting Intensities

The lighting intensities for all locations shall be in accordance to Table 2.16.2 and be considered as maintained illumination levels at the place of utilization after using a maintenance factor of 0.7

Table 2.16.2: Lighting Intensities – Illumination Levels

Location	**Plane or Place of Utilization (horizontal unless specified otherwise)**	**Light Intensity in lux**
Process Plants		
Control houses, general	1 m above floor	300
Equipment area of process control panels	panel surface	600
Local control panels	panel surface	300
Desks or tables for writing	1 m above floor	500
Compressor houses	operating areas on compressor and auxiliaries minimum at 1m above floor	200 100
Filter houses	1 m above floor	100
Pump pads and pump houses	1 m above floor	200
Ladders (fixed)	upper and lower landings	50
Vessel platforms - operating	platform level	30
Vessel platforms - ordinary	1 m above floor	20
Gauges and locally mounted instruments	at gauge	100
Extensive valve manifolds	at valves	100

General areas, within plot limits	over working	20
Power Plants		
Turbine rooms	Operating areas	200
Boiler rooms – operating aisle	1 m above floor	400
Boiler rooms – general	1 m above floor	55
Auxiliary equipment in boiler room	1 m above floor	200
Outside work areas	- over working equipment	50
	- at equipment	100
Switchgear and motor control panels	Panel surface	400
Wharves and Jetties		
Approach roadway	Road surface	30
Pire head	Road or deck surface	100
Loading manifold	At valves	100
Yard and Buildings		
Lunch rooms - general	1 m above floor	200
Lunch rooms - counters		500
Kitchens – general	1 m above floor	500
Kitchens – cooking	1 m above floor	750
Offsites, general	1 m above floor	250
Offsites, desk work	1 m above floor	500
Offsite, drafting work	1 m above floor	750
Offsite, file rooms	1 m above floor	500
Offsite, hall and stairs	1 m above floor	100
Laboratories	1 m above floor	800
Street lights	1 m above floor	50
Stair	1 m above floor	50
Housing Areas		
Bedrooms		50
Kitchen		300
Dining areas, family areas		200
Living areas		200
Toilets, entrance		100
Stairways, wash rooms		150
Car port, corridor		100

Reception, multi-purpose and central lobby areas	200
Library	300
Game rooms	250
Housing Areas (Continuous)	
Workshops – Generally inside building	400
Workshops – Nursery area	300
Terrace areas	100
Tennis courts	300
Storage – Shop storage	150
Storage – General storage	50
Stage area	300
Guard room	200
All building exterior	20

2.16.3 Normal and Emergency Lighting

a) The general design shall satisfy the conditions as per Section 2.16.1.

b) Normal and emergency lighting shall have separate circuits and wiring. Only one circuit per lighting cable is allowed. Branch lighting cable from lighting control panel to field junction boxes or lighting fixtures shall be 3 core cable (line, neutral and ground).

c) Providing normal conditions, emergency lighting shall be part of normal light and illumination.

d) The emergency lighting shall be approximately 20 % of normal lighting.

e) Same type of fittings and lamps shall be used for normal and emergency lights.

f) Intermediate emergency lighting shall be provided either with AC-lights, containing accumulator cells and inverters or with DC-lights to be connected to a separate DC-source.

Capacity of batteries shall be provided for one-hour operation of the intermediate emergency lighting.

g) Each control room and local field-mounted instrument panel shall be provided with adequate emergency lighting to enable a controlled shutdown to take place after total power failure.

This emergency lighting shall operate automatically when total loss of power. It shall be of sufficient intensity to allow reading of each instrument to be taken with all normal lighting extinguished. It shall allow for exit lighting which is provided behind main panels and equipment racks.

h) The lighting intensities are provided by the emergency illumination shall be minimum consistent with the safe and orderly shutdown of the various operating plants and/or facilities during power outages that.

2.16.4 Aircraft Warning Lights

a) Provision shall be made for aircraft warning for all structures, buildings and equipment in accordance with the regulations of ICAO (International Civil Aviation Organization) and local authorities.

b) Aircraft warning light shall have a red color globe and be installed so that being visible from all horizontal directions but in minimum at three points of one level.

c) Each light point shall be equipped with two lights so that a failure of one lamp does not eliminate the warning function.

d) The aircraft warning shall be fed from a fail-safe DC source with a battery back up for minimum one-hour. It shall be controlled similar to the general outdoor lighting by photoelectric switch.

2.17 Socket Outlets

2.17.1 General

a) Sufficient socket outlets and receptacles shall be provided within all areas for the purposes of illumination, hand tools and smaller electrical devices, welding machines and heavier construction and maintenance equipment.

b) The circuits shall be provided as follows:

Portable hand lamps	24 V AC
Electrical hand tools	220 V AC
Welding machines	380/220V, 3Ph/4W
Heavier construction and maintenance equipment	380/220V, 3Ph/4W

c) Outlets and receptacles shall be used in a suitable design for the area condition. Where they are located in hazardous areas, the explosion proof type equipment shall be provided.

d) Socket outlets of special design shall be furnished together with a sufficient number of plugs.

2.17.2 Process and Operating Areas

a) Sufficient socket outlets 220 V, 1-phase AC + PE, rated not less than 16 A and 24VAC for hand lamp shall be provided within process plants, operating areas and workshops. This is to permit illumination for visual inspection and maintenance within drums and vessels by means of a 15-m extension lead.

   Additionally to above provision, it is mandatory to have provision for LV hand tools and inspection lamps. Socket for portable hand lamps shall be provided at every manhole for all tower and drums.

   LV supply transformers shall be single phase with earthed metal screens separating the windings.

b) All sockets in the plant laboratory, workshop and off-site areas shall accept explosion-proof plugs, if required by the area hazard classification.
c) Welding outlets 380 V, 3-phase AC + PE, shall be provided in all areas and workshops.

d) Phase rotation of all welding outlets shall be the same.

e) Welding outlet sockets shall be completed with switch, rated for not less than 60 A, and of the explosion proof design in hazardous areas. It shall be designed to meet space of 30-m extension lead.

   Receptacles for heavy construction and maintenance shall be provided similar to the welding outlets in all areas.

   It shall be rated at 380/220 V, 3-phase AC + N + PE, 200 A for terminal connection of cables by mean of a 60 m extension lead.

   They shall have own circuits connected to the next LV-power bus.

   Explosion proof design shall be provided for receptacles as per section 1.3.

f) Socket and receptacles shall be used with socket and receptacles installed in existing plant.

2.17.3 Building Installation

In offices, substation, and similar accommodation, domestic type outlets to local standards shall be provided. Power units supply that integrate socket, high speed LAN and telephone connection shall be used in general.

2.18 Cathodic Protection

For specific requirements for Cathodic Protection are given in specification ES-92-07.

2.18.1 Cathodic protection, shall be provided for corrosion control of metallic structures and equipment exposed to soil and water environment and protect the following objects continuously for a period of 20 years:

a) Buried pipe work, e.g. circulating water lines, fuel lines, fire water piping, etc.

b) Condenser water box internal surfaces.

c) Buried fuel tanks.

d) Bottom of at-grade tanks in direct earth contact

e) Sea water heat exchangers and piping, if any

Soil investigations with soil resistivity tests shall be conducted.

2.18.2 The cathodic protection application shall be of the impressed current system or sacrificial anodes where practicable to reverse the electrolysis effect of corrosive soils and water.

2.18.3 The cathodic protection application and measure shall be accordance with the following or equivalent referenced standards:

a) American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI), Publication B 31 G “Corrosion Control for Power Piping System”

b) National Association of Corrosion Engineers (NACE) RP-01-69 and RP-05-72 “Recommended Practice for Control of External Corrosion on Underground or Submerged Metallic Piping System”

c) British standard Institution CP 1021 – Code of Practice for Cathodic Protection

2.18.4 The anodes grounded shall be designed for 30 years continuous operation.

The number and location of anodes shall be determined as the following basis:

a) A uniform and ample current distribution will be obtained

b) Taking the soil resistivity

c) Extra current demand for earthing

d) External coating specification of the protected pipe

e) Specification of tank foundation

f) Characteristics/size of anodes and interference into account.

The Contractor shall design and verify the suitability of the grounded location to the latest plot plan arrangement.

Galvanic anodes where practicable shall be magnesium alloy and also designed for a period of 30 years for permanent system.

2.18.5 Interference of existing cathodic protection systems with the designed system shall be considered.

2.18.6 Electrical separation (e.g. insulating joints) shall be considered where necessary.

Insulating joints shall be installed as follows:

a) To isolate the cathodically protected pipes or tanks from other pipes or structures which would increase the current demand of the system.

b) To segregate long pipes, complicated buried pipes or tanks into sections when current demand of various pipe sections are substantially different.

c) Type of insulating joints and flange shall be selected under consideration of pipe diameter and the type of fluids carried by the pipes (e.g. electrically conductive fluids).

d) Also coating of internal pipe surface at the surroundings of insulating flange shall be considered.

In addition to insulating joints, electrical separation of the protected object from the following shall be considered:

a) Instrument cable conduit

b) Reinforcing steel bar in concrete

c) Road crossing steel pipes

d) Steel pipe support

e) Earthing network system

2.18.7 Test Points

For the process area and the in-plant power generation unit permanent test leads terminating in junction boxes shall be provided at the following locations for potential measurement of buried pipes and tanks:

a) Buried insulating joints

b) Steel pipes for road crossing

c) Foreign pipe crossing

d) Galvanic anode installation

e) Other points along the pipe system, as necessary to completely monitor the protection system

f) Point where the highest potential is expected

g) Point where the lowest potential is expected

h) Tanks

Thermoswelding process shall be applied for connecting the wires (one wire shall be used as back up) to the object surface.

2.18.8 Reference Electrode

Permanent type reference electrode shall be provided for potential measurement at test points located in concrete paved areas.

Permanent type reference electrode shall be provided at center of tank foundation to monitor the potential of inaccessible and critical point.

2.18.9 Electrical Bonding

Bonding shall be provided across any insulated pipe sections, valves and expansion joint to ensure electrical continuity of the buried pipes.

Bonds of proper resistance shall be provided as required between the protected pipes and affected pipes or structures which may need interference current control.

2.18.10 Temporary Protection

Temporary cathodic protection is required for buried pipes, which will not be protected by permanent cathodic protection within three months after pipe installation.

Magnesium anodes shall be installed at test point for temporary protection during the pipe installation.

The pipe potential shall be measured after the anode installation.

The quantity of anode required shall be determined after potential measurement.

2.18.11 Spark Gap

Spark gap shall be provided across each insulating joint to protect the joint and avoid sparks likely to be caused by lighting.

Installations in hazardous and classified areas shall be highly considered.

2.19 Electrical Substations and Transformer Stations

2.19.1 Substations and transformer stations shall be provided within the Ethane Separation Plant area and PTT Central Substation as follows.

The substation and transformer station shall be positioned as per Electrical Equipment Layout for Ethane Separation Plant /PTT Central Substation DWG No. 79-0-0504.04-3268-001 and PTT-101-003A, respectively.

2.19.2 Location of Substations and Transformer Stations

a) Substations shall be located in non-hazardous areas.

b) Step-down transformers shall be located in the open air adjacent to the substation for which they are needed, except for smaller items, e.g. dry-type transformer and transformers for instrument power or socket outlets. The latter ones shall be located within the substation building.

2.19.3 Substation Buildings and electrical room

a) The substation buildings and electrical room shall be of solid, fireproof construction, located in safe areas and may combine switchgear and control gear in the same room.

b) It shall be air-conditioning, except for cable room, CO2 storage tank and diesel generator set room

c) Separate battery rooms shall be provided with sufficient ventilation due to degassing of batteries.

d) All electrical equipment, wiring and installation in battery room shall be conformed to explosion proof standard.

e) It shall include a cable basement for cable entering from below into the switchgear, control gear and other facilities except minor items. Local switchrooms of a smaller size may be provided with elevated cable floor only (e.g. for control room, Instrument Rack Room).

f) Sufficient ventilation shall be provided for non-air-conditioning room in substations or individual switchrooms, providing that the temperature rise under full load conditions of equipment shall not exceed 5 degree Kelvin.

g) The buildings and rooms shall be protected against dust, fumes, water, over floating and the ingress of birds, snakes, vermin, insects and rodents. Openings for cable entering into the building shall be carefully closed and sealed.

h) Only authorized personnel shall enter into substations and switchrooms. It shall be secured by key locked doors.

i) Smoke detectors shall be provided in the equipment room(s) as well as in the cable basement (s) for fire alarm purposes.

2.19.4 Open Air Transformer Stations

For oil-immersed type transformers, the following shall be provided:

a) The transformers shall be installed outdoors within fenced bays. Key-locked gates shall be provided.

b) Walls shall be provided between the boxes for fire protection purposes. Wall shall be provided reach up to the roof.

c) Concrete oil pits shall be provided below the transformers in order to contain any oil spillage. A facility shall be provided to enable removal of storm water.

d) Sun and weather protection shelters shall be provided for all transformer bays.

e) Stainless steel mesh for protect birds entering into transformer bay shall be provided.

2.19.5 Indoor Transformer Stations

Only dry-type transformers of smaller sizes up to 350 kVA shall be installed inside of buildings. In those cases, the following shall be provided:

a) Dangerous contact of personnel to live parts must be prevented by metallic covers and minimum IP31 degree of protection.

b) Sufficient ventilation shall be provided.

2.19.6 Current Limiting Reactors

Current limiting reactors, if any, shall be installed in separate rooms, which are sufficiently ventilated. Special care to be taken for magnetic fields produced by the reactance coils.

2.19.7 Is Current Limitter

Is Current limiting, if any, shall be installed at removable compartment of 11kV switchgear located inside substation. It shall be strictly considered short circuit calculation in order to limit fault current against the existing switchboard rating.

2.20 Temporary Power Supply

2.20.1 CONTRACTOR shall provide a temporary power supply for the several areas as per requirement.

2.20.2 CONTRACTOR shall determine his requirement areawise. Provision shall be made for power supply either from the existing facilities or diesel engine driven alternators to be provided by the Contractor according to the areawise possibilities and availability.

2.20.3 CONTRACTOR shall specify the system in his bid accordingly.

2.21 Design Procedures

2.21.1 General Requirements

a) All electrical equipment shall be completely tagged and referenced on one-line diagrams and data sheets.

The reference numbers shall identify type, function and location of equipment and include voltage level, in case of power equipment.

Equipment itself shall be physically tagged with reference number, in an indelible and clear fashion.

b) Tag or reference numbers must be unique and not duplicated in other plants, sections or areas of complex.

c) Main and auxiliary electric drivers, generators and heaters shall be tagged with same numbers as used for equipment in P&ID already, but identified by adding the letters M (Motor), G (Generator) and H (Heater) for example, CM – Motor for compressor, PM – Motor for pump.

d) Interlocks and sequence shall be shown together with direction of operation on P&ID and electrical drawings.

e) Motor starters including correspond facilities shall be fully identified.

f) All equipment shall be adequately labelled and such labels shall be so fitted as to prevent interchange of labels.

All removable units shall be clearly labelled with number (e.g. motor number) and title.

g) All switchgear and control gear for similar services must be of identical performance (e.g. type, fault rating and wiring). This feature is to provide the maximum inter-changeability.

h) CONTRACTOR shall provide with his bid an estimate of power consumption for all areas in each of the following categories:

i) Installed driver rating

ii) Normal running load based on 100 % operated facilities

iii) Peak load and maximum demand required for plant operation and system sizing

iv) Highest inrush load on used voltage levels

v) Emergency power demand to be supplied from diesel generator

vi) General loads (e.g. for lighting, instrument power, etc) shall be also considered herein.

2.21.2 Design Documentation

a) The design documentation shall cover all requirements for system and equipment design, selection of equipment and material as well as complete installation, and shall be furnished in the English language.

b) The contractor shall be responsible for rightness and reliability of the complete design, included in his scope of work.

c) The design documentation shall include but not be limited to the following documents.

  i) Area classification drawings

  ii) Electric Motors and Consumers List showing tag number, ratings, data, operation and load status of concerned equipment and systems.

  iii) One-line diagrams

  iv) Software to be used during design shall be submitted to PTT/Consultant for review/comment.

  v) Basic design studies, for system design such as load calculations. Voltage dips and drops calculations. determination of natural and improved power factor, calculation of fault ratings, short circuit calculation, load shedding and motor reacceleration study, harmonic study, Transient Stability Study, Protective Relay Coordination Study, and all necessary study for engineering purpose.

  The calculation shall cover all operating condition.

  All above calculation shall be done on “ETAP, Power Solution Soft ware”.

  Reviewing on above calculation shall be done on ETAP program. Final document shall be submitted both hardcopy and software data. Provision for training before reviewing shall be included in contractor scope of supply.

  vi) Schematic, wiring and connection diagrams for all equipment.

  vii) Protective relay co-ordination schemes and grading lists.

  viii) Logic diagrams for electronic circuits and complicate sequence controls and interlocking, including PLC software. PLC logic sequence shall be clearly stated of comments.

  ix) Arrangement drawings showing position of individual equipment (e.g. motor feeder position in MCC).

  x) Power, lighting, earthing and communication layout drawings showing cable routes and runs, cable tray and construction details.

  xi) Construction standard sheets, showing the details for mounting and connection of individual equipment.

  xii) Substation and switchroom layout drawing with installation details, including transformers.

xiii) Assembly drawings for systems and equipment (e.g. generators, auxiliary supplies etc), showing arrangement and location of all concerned equipment and auxiliaries.

xiv) Cable and wire schedules.

xv) Equipment and material lists, showing CONTRACTOR complete scope of supply and also the exceptions.

xvi) Requisitions, specifications and data sheets for all electrical equipment and materials.

xvii) Specification for equipment testing

d) The design documentation shall contain all specific requirements of the several areas and facilities and be subdivided clearly, so that it can be easily used during construction.

e) CONTRACTOR to prepare final as built drawings covering final status and arrangement of all systems and equipment.

f) CONTRACTOR to furnish completes manuals, containing all documents of design as well as equipment and material.

The manuals shall be clearly labeled with item numbers and titles of system and equipment concerned. The use of general manuals is permitted for minor items of equipment only.

3.0 DOCUMENTATION

3.1 CONTRACTOR to furnish completes equipment manuals for his scope of supply, covering all information needed for construction, commissioning, operation and maintenance of equipment and sub-equipment in the English language.
All documents shall be editable Microsoft based electronics files with searching program facility.

3.2 The equipment documentation shall include the following documents, but shall not be limited to them:

a) Equipment data sheets, showing design and label data of relevant equipment

b) Certificates for all equipment, showing its conformity to the applied standard, codes and specifications, issued by the manufacturer

c) Certificates for all explosion-proof type equipment, issued by an authorized test organization and the responsible authority

d) One-line diagrams of power wiring

e) Schematic, wiring and connection diagrams, showing the as-built status of equipment and wiring

f) Outline dimensional drawings and front views

g) Assembly and arrangement drawings, showing location of equipment (e.g. switchgear and control gear)

h) Part lists, using identical reference numbers as specified in electrical diagrams

i) Logic diagrams for solid state circuits and complicated control circuits, also when conventionally performed

j) Instructions for construction, commissioning, operation and maintenance of all electrical equipment and materials

k) Grading and calibration schemes and data

l) Test certificates for all equipment, covering type tests already performed as well as acceptance test results, and containing all definite data and diagrams, determined in the tests

m) Data sheets of essential devices such as circuit breakers, protective relays, solid-state circuits, containing reference points and values for equipment testing and checking

n) List of special tools, required for construction and maintenance

o) List of wearing parts, including intervals for replacement of these parts

p) List of space parts, recommended for spare part stock and a 2-year operation period

q) Bearing and lubrication list, showing specification, intervals and quantity of lubricants to be used

r) Instructions for electrical machines shall allow repair and replacement of windings in Thailand

s) CONTRACTOR to furnish all documents in a good guilty and the required number of sets.

4.0 TESTING

4.1 All tests to be performed shall be in accordance with the relevant standards and codes to be followed in the job and the conditions specified below.

Further conditions shall be considered in accordance with the relevant sections of this specification, but also specification no. ES-95.70.

4.2 All major electrical equipment, motors, switchgear, transformers, generators, auxiliary power and communication equipment shall be tested at the manufacturer’s workshop before shipment. The CONTRACTOR shall witness these tests.

4.3 Wherever possible, full-load tests shall be conducted on equipment.
Such full-load testing is not required for items such as switchgear and motor control gear, which have been fully type-tested.
Generators, motors that have not been type tested shall be fully tested at the manufacturer’s works before shipment.

4.4 Tests of equipment shall include full-load performance tests and test certificates shall be completed and certified by the manufacturer concerned.

4.5 Control equipment and electrical system protection devices shall all be fully tested in the manufacturer's work after installation in the corresponding panels providing also full functional tests of equipment.

The equipment shall be dispatched with all relays, time delays, trip devices, etc, correctly set at the required settings.

4.6 The same procedure shall be performed for all converter and communication equipment, which shall also be tested regarding its characteristics.

4.7 All such devices shall be retested for proper calibration after installation at the plant site is complete.

4.8 The Contractor shall carry out the following tests and inspections as a minimum before making any circuit live:

a) A visual inspection of both ends of the cable/conduit run, and all intermediate joints, to ensure that terminal chambers and other enclosures are clean, joints tight and sound, wiring correctly dressed and labelled, and no obvious faults are present.

b) Protective relays, fuses and overloads must be checked for setting and corrected where necessary.

c) Checking of alignment, bus-bar connections, moving of withdrawal type switchgear, breaker drive function, mechanical interlocks, etc, shall also be performed as well as checking of tightness and proper sealing.

d) After the visual inspection, all possible covers shall be replaced and cover screws (and gaskets, if any) checked to be present and tight.

e) Electrical tests shall include:

i) An insulation test for each winding and circuit, with a separate test for each core of the power circuits

ii) A high-voltage pressure test for all cables working at above 400 V

iii) A continuity test for all power circuit wiring and windings

iv) An earth continuity test for all circuits

v) An earth resistance measurement for each group of earth electrodes, and the earthing system as a whole

vi) Lighting installation shall be tested for correct illumination levels with the fittings as installed. Fittings shall be operated only with their designed size (or less) of lamp or tube

4.9 After the above inspection and tests are completed, control circuits shall be tested for correct operation under all possible operating combinations, and proved correct before applying power to main circuits.

4.10 Main circuits shall be checked for correct phasing and rotation.

4.11 All communication system and circuits shall be checked for correct operation.

4.12 After making circuits live, the following tests shall be conducted for circuits and equipment:

a) No-load and load tests for all power supply and rotating equipment.

b) Functional test of emergency and auxiliary power supplies under operating conditions.

4.13 Determination of large motor starting features.

4.14 A close visual inspection of all electrical equipment in hazardous areas shall be made to ensure that equipment is both suitable and correctly installed.

4.15 For testing and commissioning of the cathodic protection system refer to std. ES-92.07.

PTT PUBLIC CO., LTD

ENGINEERING STANDARD

REVISION	REV 0	REV 1	REV 2	REV D1	REV D2
DATE	MAR 15, 05	AUG 9, 06			
ORIG.BY	WORATAT B.	TEERUT S.			
APP.BY	WISUT N.				
SIGNATURE					

TABLE OF CONTENTS

1. SCOPE

This specification defines the minimum requirements for the design, manufacture, inspection, testing, packing and shipping of Electrical and Instrumentation Cables for the PTT Project hereinafter referred to as the Plant.

Plant electrical cables are categorized as follows:

- Medium voltage (33 kV, 22 kV, 11 kV and 6.9 kV) power cables.
- Low voltage (380/220 Vac, 125 Vdc, 24 Vdc) power and lighting cables.
- Control cables.
- Fire resistant cables.
- Grounding cables.

Plant instrumentation cables are categorized as follows:

- Signal cables for general instrumentation.
- Signal cables for fire and gas detection service and Plant communication.
- Cables for instrumentation power signals.
- Cables for fire and general alarm protection service.
- Thermocouple cables.
- Computer and data transmission cables.

2. DEFINITIONS

Company	:	PTT (PTT Public Company Limited)
Contractor	:	The party that carries out all or part of the EPCC contract.
Purchaser	:	Company or Contractor as specified in the covering letter of the inquiry document.
Vendor	:	Manufacturer/Supplier/Vendor is the party that manufactures or supplies equipment and services to perform the duties specified by the Purchaser.

3. APPLICABLE CODES, STANDARDS AND REGULATIONS

The applicable sections, latest editions and supplements of the following codes, standards and regulations, unless modified herein, shall constitute minimum requirements and form part of this specification:

IEC 60228	-	Conductors of insulated cables.
IEC 60228A	-	First supplement: Guide to the dimensional limits of circular conductors.
IEC 60331	-	Fire-resisting characteristics of electric cables.
IEC 60332-1-2	-	Tests on electric and optical fiber cables under fire conditions - Part 1-2: Test for vertical flame propagation for a single insulated wire or cable - Procedure for 1 kW pre-mixed flame
IEC 60332-3	-	Tests on electric cables under fire conditions.
IEC 60502-2	-	Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV.
IEC 60540	-	Test methods for insulation and sheaths of electric cables and cords (elastomeric and thermoplastic compounds).
IEC 60754	-	Tests on gases evolved during combustion of electric cables.
IEC 60811	-	Common test methods for insulating and sheathing materials of electric cables.
IEC 60815	-	Electrical test methods for electrical cables.
IEC 60815-2	-	Partial discharge tests.
IEC 61034-1	-	Measurement of Smoke Density of Cables Burning Under Defined Conditions - Part 1: Test Apparatus
IEC 61034-2	-	Measurement of Smoke Density of Electric Cables Burning Under Defined Conditions - Part 2: Test Procedure and Requirements
BS 5308	-	Instrumentation cables.

BS 4066 Part 3	-	Test on electric cable under fire conditions: Method of classification of flame propagation characteristics of bunched cables.
BS 5467	-	Cables with thermosetting insulation for electricity supply for rated voltages up to and including 1900/3300 V.
BS 6004	-	PVC insulated cables (non-armoured) for electric power and lighting.
BS 6360	-	Conductors in insulated cables and cords.
BS 6469	-	Methods of test for insulation and sheaths of electric cables.
BS 6387	-	Performance requirements for cables required to maintain circuit integrity under fire conditions.
BS 6622	-	Cables with extruded cross-linked polyethylene or ethylene-propylene rubber insulation for rated voltages from 3600/6600 V up to 19000/33000 V.
BS 6746	-	PVC insulation and sheath of electric cables.

Any conflict between this specification and referenced documents shall be brought to the attention of the Company in writing for resolution. In general, the order of precedence is:

- Thai national laws, statutory and local authority regulations.
- This specification.
- Referenced codes and standards.

Compliance with this specification does not relieve the Contractor of the responsibility of supplying cables of proper design and construction and full suitability for all the specified operating conditions.

4. DESIGN DATA

4.1 Environmental Conditions

The electrical cables shall be suitable for use in the site environmental conditions as detailed in 'Basis of Design'.

Electrical cables shall be protected against the adverse effects of temperature, ultra-violet radiation from sunlight, high humidity, dust, salt-laden air, hydrocarbons and corrosive industrial substances.

Electrical cables laid direct buried in ground or laid in sand-filled concrete trenches shall have their sheath impregnated with an anti-termite repellent such as copper napthanate or provided with suitable alternative anti-termite protection.

5. MATERIALS AND DESIGN

Materials shall be new and of high quality. Cables offered must be of current proven design. Prototype materials and designs are not acceptable.

6. TECHNICAL REQUIREMENTS

6.1 Electrical Cables

6.1.1 General Requirements

All Plant electrical cables shall have:

- flame retardant characteristics with an oxygen index of not less than 30 and temperature index of not less than 300 °C, and
- an oversheath that is sunlight resistant and oil/hydrocarbon resistant.
- a minimum service life of 20 years continuously carrying full load current.

Flame retardant cables shall comply with IEC 60332 Part 3 Category A (or BS 4066 Part 3 Category A) incorporating specially formulated PVC compounds for insulation, bedding, inner sheath and oversheath.

All Plant power, control and lighting cables shall be suitably filled, substantially compact and circular in construction with extruded bedding and non-hygroscopic interstitial fillers to minimize the use of compound barrier cable glands in hazardous areas.

Cable armour shall be galvanized steel wire armour (SWA) for multi-core cables and non-magnetic aluminium wire armour (AWA) for single core cables. Galvanized steel wire braid (SWB) armour shall be used for multi-core lighting cables for conductor sizes up to 16 mm^2 where flexibility of bending of the cables is required.

Multi-core electrical cables shall be used in preference to single core cables. However single core cables may be used for practical or economic reasons, e.g. generator and transformer secondary cables or in case of high current ratings where two parallel multi core cables of the largest cross section permitted would not suffice.

For inverter or variable speed drive application, symmetrical conductor cable with braid copper screening such as NYCWY (symmetrical construction) or HELUKABEL TOPFLEX®.

For grounding application, overheath color of cables shall be green with yellow stripe.

6.1.2 Construction

6.1.2.1 Medium Voltage (33 kV, 22 kV, 11 kV and 6.9 kV) Power Cables

Medium voltage power cables are used:

- To connect the stator winding terminals of the gas turbine driven generators to the switchboard busbars (using single core cables).
- To connect the power system neutral (generator star-point) to ground through a grounding resistor (using single core cables).
- To connect the secondary winding terminals of the power transformers to the switchboard busbars (using single core cables).
- To connect the power system neutral (transformer star-point) to ground through a grounding resistor (using single core cables).
- As feeder cables to medium voltage motors, power transformers and medium voltage power factor correction capacitors.

Medium voltage three core cables shall have a minimum cross-sectional area of 25 mm^2 and a maximum cross-sectional area of 240 mm^2.

The construction of armoured single core medium voltage power cables shall be as follows:

Standards	:	IEC 60502 or BS 6622.

Voltage	:	Uo/U (Um) rms = 18/30 (36) kV rms for 33 kV power system or Uo/U (Um) rms = 12/20 (24) kV rms for 22 kV power system or Uo/U (Um) rms = 8.7/15 (17.5) kV rms for 11 kV power system or Uo/U (Um) rms = 6/10 (12) kV rms for 6.9 kV power system.

U_o is the rated power frequency voltage between conductor and metallic screen, for which the cable is designed,

U is the rated power frequency voltage between conductors, for which the cable is designed, and

U_m is the maximum value of the "highest system voltage" for which the equipment may be used.

Conductor	:	Plain annealed high conductivity copper circular stranded to IEC 60228 Class 2.
Conductor screen	:	Extruded semi-conducting XLPE layer.
Insulation	:	Extruded cross-linked polyethylene (XLPE) to BS 5469.
Insulation screen	:	Extruded semi-conducting XLPE layer with semi-conducting tape and overlapping copper tape screen over the core.
Inner (separation) sheath	:	Extruded layer of flame retardant black PVC compound with oxygen index not less than 30, temperature index not less than 300 °C and complying with Class ST2 of IEC 60502.
Armour	:	Single layer of round non-magnetic aluminium wires.

Oversheath	:	Flame retardant PVC complying with ST2 of IEC 60502.
Oversheath Colour	:	Red.

Conductor screen, insulation and insulation screen shall be extruded simultaneously in one operation using the triple extrusion process. The insulation layer shall be distinguishable and easily strippable from the semi-conducting layers without the need for special tools or heat sources.

The construction of armoured three cores medium voltage power cables shall be as follows:

Standards	:	IEC 60502 or BS 6622.
Voltage	:	Uo/U (Um) rms = 18/30 (36) kV rms for 33 kV power system or Uo/U (Um) rms = 12/20 (24) kV rms for 22 kV power system or Uo/U (Um) rms = 8.7/15 (17.5) kV rms for 11 kV power system or Uo/U (Um) rms = 6/10(12) kV rms for 6.9 kV power system.
Conductor	:	Plain annealed high conductivity copper circular stranded to IEC 60228 Class 2.
Conductor screen	:	Extruded semi-conducting XLPE layer.
Insulation	:	Extruded XLPE to BS 5469.
Insulation screen	:	Extruded semi-conducting XLPE layer with semi-conducting tape and overlapping copper tape screen over the core.

Core identification	:	Red, Yellow, Blue.

The three power cores shall be laid up with non-hygroscopic fillers in round shape and a suitable binder tape shall be applied helically over the cabled cores.

Inner sheath (bedding)	:	Extruded layer of flame retardant black PVC compound with oxygen index not less than 30, temperature index not less than 300 °C and complying with Class ST2 of IEC 60502.
Armour	:	Single layer of galvanized round steel wires.
Oversheath	:	Flame retardant PVC complying with ST2 of IEC 60502.
Oversheath Colour	:	Red.

Conductor screen, insulation and insulation screen shall be extruded simultaneously in one operation using the triple extrusion process. The insulation layer shall be distinguishable and easily strippable from the semi-conducting layers without the need for special tools or heat sources.

6.1.2.2 Low Voltage Power and Lighting Cables

Low voltage power and lighting cables, both single and multi-core, comprise the bulk of the Plant cables.

Single core construction shall be used for large power cables (240 mm^2 and above, e.g., transformer secondary cables).

Generally single core cables installed in the Plant shall be armoured with non-magnetic aluminium wires. Single core low voltage cables may be non-armoured where they are installed in locations (e.g. in substation buildings) where the risk of mechanical damage is minimal.

The construction of armoured single core low voltage power cables shall be as follows:

Standards	:	IEC 60502 or BS 5467
Voltage	:	Uo/U rms = 0.6/1 kV rms where

U_o is the nominal voltage between conductor(s) and ground, and

U is the nominal voltage between phase conductors.

Conductor	:	Plain annealed high conductivity copper stranded to IEC 60228 Class 2 (circular up to 16 mm^2 and shaped stranded for 25 mm^2 and above).
Insulation	:	Extruded cross-linked polyethylene (XLPE) to BS 5469.
Bedding	:	Extruded layer of flame retardant black PVC compound with oxygen index not less than 30, temperature index not less than 300 °C and complying with Class ST2 of IEC 60502.
Armour	:	Single layer of round non-magnetic aluminium wires.
Oversheath	:	Flame retardant PVC complying with ST2 of IEC 60502.
Oversheath Colour	:	Black

The construction of armoured multi-core low voltage power cables shall be as follows:

Standards	:	IEC 60502 or BS 5467
Voltage	:	0.6/1 kV
Conductor	:	Plain annealed high conductivity copper stranded to IEC 60228 Class 2 (circular up to 16 mm^2 and shaped stranded for 25 mm^2 and above).
Insulation	:	Extruded cross-linked polyethylene (XLPE) to BS 5469.
Core identification Phase conductors	:	Red, yellow, blue for cables with or without neutral conductor.

Neutral conductor	:	Black.
Protective conductor (for all cable)	:	Green with yellow stripe

The required number of cores shall be laid up with non-hygroscopic fillers in round shape and a suitable tape may be applied helically over the cabled cores.

Inner sheath (bedding)	:	Extruded layer of flame retardant black PVC compound with oxygen index not less than 30, temperature index not less than 300 °C.
Armour	:	Single layer of galvanized round steel wires.
Oversheath	:	Flame retardant PVC complying with ST2 of IEC 60502.
Oversheath Colour	:	Black.

For battery application, conductor shall be fine strands of high quality plain copper wire.

Color identification for single phase load (such as lighting load) shall be black for phase conductor and white for neutral conductor.

Color identification for dc application (such as battery) shall be red for positive polarity and white for negative polarity.

6.1.2.3 Control Cables

Standard	:	IEC 60502 or BS 5467
Voltage	:	0.6/1 kV
Conductor	:	Plain annealed high conductivity stranded copper complying with IEC 60228 Class 2
Insulation	:	Extruded cross-linked polyethylene (XLPE) to BS 5469
Protective conductor	:	Green with yellow stripe

Control conductors	:	Black with Numbers on cores, from 1 up to number of total control cores
Protective conductor	:	Green with yellow stripe

The required number of cores shall be laid up with non-hygroscopic fillers in round shape and a suitable tape may be applied helically over the cabled cores.

Inner sheath (bedding)	:	Extruded layer of flame retardant black PVC compound with oxygen index not less than 30, temperature index not less than 300 °C.
Armour	:	Single layer of round galvanized steel wires
Oversheath	:	Flame retardant PVC complying with ST2 of IEC 60502.
Oversheath Colour	:	Black

6.1.2.4 Fire Resistant Cables

Fire resistant cables shall be 0.6/1 kV grade, multi-core, stranded copper conductor, insulated with a fire resistant layer of mica glass tape applied helically with the mica in contact with the conductor, steel wire armoured (SWA) or steel wire braided (SWB), PVC oversheathed. Cable construction shall be to IEC 60502 and IEC 60331 or BS 6387. Oversheath colour shall be orange.

This cable type shall be used for supplying emergency lighting luminaires and for other vital circuits in the Plant and buildings supplied from the AC and DC uninterruptible power supply systems.

The construction of armoured multi-core low voltage fire resistant cables shall be as follows:

Standards	:	IEC 60502, IEC 60331 and BS 6387 Category B
Voltage	:	0.6/1 kV

Conductor	:	Plain annealed high conductivity copper stranded to IEC 60228 Class 2 (circular up to 16 mm^2 and shaped stranded for 25 mm^2 and above).
Insulation	:	Extruded cross-linked polyethylene (XLPE) to BS 5469.
Fire resistant barrier	:	Layer of mica-glass tape applied helically with the mica in contact with the conductor. Cable must withstand a temperature of 750 °C for 3 hours (IEC 60331 or BS 6387 Category B test method).
Core identification Phase conductors	:	Red, yellow, blue for cables with or without neutral conductor.
Neutral conductor	:	Black.
Protective conductor (where specified)	:	Green with yellow stripe

The required number of cores shall be laid up with non-hygroscopic fillers in round shape and a suitable tape may be applied helically over the cabled cores.

Inner sheath (bedding)	:	Extruded layer of flame retardant black PVC compound with oxygen index not less than 30, temperature index not less than 300 °C.
Armour	:	Single layer of galvanized round steel wires.
Oversheath	:	Flame retardant PVC complying with ST2 of IEC 60502.
Oversheath Colour	:	Orange.

6.1.2.5 Grounding Cables

Standard	:	BS 6004.
Voltage	:	450/750V.
Conductor	:	Plain annealed high conductivity stranded copper complying with IEC 60228 Class 2.
Insulation	:	Extruded polyvinyl chloride (PVC).
Insulation Colour	:	Green with yellow stripe.

7. CABLE MARKING, DRUMMING AND PACKING

7.1 Cable Marking

The oversheath of each cable shall be marked to allow clear legibility of cable data as follows:

- Manufacturer’s name and year of manufacture.
- Voltage grade.
- Cable type.
- Number of cores and core size.
- IEC/BS (if cable fully complies with the applicable standard).
- Length marking at every metre.

7.2 Cable Drum Marking

Each cable drum shall be marked with a permanently-attached stainless steel label showing the following information:

- Company’s project name
- Contractor’s purchase requisition number.
- Manufacturer’s name.
- Manufacturer’s job number.
- Manufacturer’s works name where the cable has been manufactured.
- Drum size.
- Drum number.
- Cable type.

- Voltage grade.
- Number of cores and core size.
- Exact cable length on drum (m).
- Weight of cable (net weight in kg).
- Weight of cable drum (kg).
- Total weight (gross weight in kg).

For the medium voltage cables, an additional permanently-attached stainless steel label shall indicate the motor/panel tag numbers that the respective supply cables on the drum are assigned to.

7.3 Drumming and Packing

All drum cables shall be continuous without splices. Low voltage cables with size above 50 mm^2 and all medium voltage and high voltage cables shall be coiled on drums in detailed specified lengths.

Cable ends shall be sealed with heat-shrunk end cap immediately after testing to protect the cables from ingress of moisture.

Cables shall be shipped on non-returnable steel or wooden drums of robust construction and fully lagged with wooden battens or covered to avoid any damage to the cables during transportation, storage and handling. Packing life shall be a minimum of 6 months. The clearance from the perimeter of the drum flange to the outermost layer of cable shall be at least 50 mm or one cable diameter, whichever is larger.

8. QUALITY ASSURANCE

8.1 General

The Vendor shall operate a quality system satisfying the provisions of ISO 9001 or agreed equivalent standard, commensurate with the goods and services provided.

8.2 Inspections During Manufacturing

The Company reserves the right to carry out at least one inspection during manufacturing.

8.3 Factory Tests

The Company will witness factory tests when the electrical cables have been manufactured and are in "ready for dispatch" condition.

8.3.1 Factory Tests For Electrical Cables

All tests including but not limited to the following tests as per the relevant IEC/BS standards shall be performed on each cable. Test certificates shall be submitted to the Company.

8.3.1.1 Inspections

- Visual inspection for concentricity, dimension checks and cable marking, etc.

8.3.1.2 Routine Tests

- Spark tests on conductor insulation and oversheath.
- Conductor resistance measurements.
- Partial discharge tests (for medium voltage cables only).
- High voltage tests on completed cable (at 50 Hz for 5 minutes).
- Continuity tests for conductor and screen.

8.3.1.3 Special Tests

- Conductor examination by inspection and measurement for compliance to IEC 60228 (or BS 6360).
- Check on thickness of insulation, inner (separation) sheath, braid and armoring wires, sheath, etc.
- Voltage test on medium voltage cables (at 50 Hz for 4 hours).
- Hot set test for XLPE insulation and sheath.
- Fire resistance tests to IEC 60331 or BS 6387 type B.

8.3.1.4 Type Tests

- Electrical, for medium voltage cables as per Table 5 of IEC 60502.
- Non-electrical, as per Table 6 of IEC 60502 including flame retardant tests to IEC 60332 Part 3 Category A (or BS 4066 Part 3 Category A).

9. DOCUMENTATION

9.1 Documentation Required With Vendor's Bid

The following documents shall be supplied with the Vendor's bid:

- Manufacturers' technical brochures.
- Cable specification, description, technical data and applicable standards.
- Documentary evidence that type tests have been performed at the Manufacturers' works or at a recognized testing authority to very that all cable designs offered can perform to the design standards.
- Cross-sectional view of each cable type showing the material construction and dimensions.
- Manufacturers' standard quality assurance and quality control procedures.
- References for oil and gas, petrochemical and industrial projects.

มาตรการจัดการโรคติดต่อ COVID-19

ผู้รับจ้างจะต้องดำเนินการบริหารจัดการสถานการณ์โควิด-19 ตามวิธีการที่ ปตท. และหน่วยงานราชการกำหนดดังนี้

1. ผู้รับเหมาทุกคนที่จะเข้าปฏิบัติงานในเขตพื้นที่สำนักงานและโรงงานของ ปตท. จะต้องผ่านการอบรมความปลอดภัยจาก ปตท. จนได้รับบัตรผู้รับเหมาชั่วคราว และผ่านการคัดกรองโรค COVID-19 จนได้รับบัตร COVID-19 Pass
2. ขั้นตอนเพื่อขอรับบัตร COVID-19 Pass

2.1. ปตท. ได้กำหนดวิธีการคัดกรองผู้รับเหมาที่จะเข้ามาดำเนินการในพื้นที่ของ ปตท. เพื่อป้องกัน และลดความเสี่ยงในการแพร่ระบาดของ COVID-19 แล้วแต่กรณี ดังนี้

กรณีที่ 1 พนักงานของผู้เสนอราคาที่**มาจากต่างพื้นที่ ซึ่งมิได้เป็นจังหวัดตามสถานที่ตั้งของหน่วยงาน ปตท.** ที่ผู้เสนอราคาจะเข้ามาปฏิบัติงาน

- พนักงานของผู้เสนอราคาจะต้องปฏิบัติตามมาตรการของจังหวัดที่จะเดินเข้ามา เช่น การตรวจหาเชื้อโรค COVID-19 ด้วยวิธี RT-PCR และนำผลตรวจมายื่นรายงานตัวต่อนายอำเภอ กำนัน หรือ ผู้ใหญ่บ้านที่ดูแลพื้นที่ที่จะเข้ามาพักอาศัยและนำผลดังกล่าวยื่นให้กับทาง ปตท. ทราบด้วย
- เมื่อเข้ามาพักอาศัยในพื้นที่จังหวัดซึ่งเป็นสถานที่ตั้งของสำนักงาน ปตท. ที่เสนอราคาจะเข้ามาปฏิบัติงาน พนักงานของผู้เสนอราคาจะต้องกักตัว และปฏิบัติตามมาตรการการป้องกันการแพร่ระบาดของ COVID-19 ที่ ปตท. และรัฐกำหนด เป็นระยะเวลาทั้งสิ้น 14 วัน ก่อนถึงวันเข้าปฏิบัติงาน
- ผู้รับจ้างมีหน้าที่แจ้งความจำนงเพื่อเข้าตรวจหาเชื้อ COVID-19 โดยวิธี Anti-gen test KIT (ATK) กับ ปตท. ก่อนหรือในวันที่เข้าปฏิบัติงาน โดยจะต้องจองวันตรวจในระบบของ ปตท. ล่วงหน้าอย่างน้อย 2 วัน
- วันที่ 14 ของการกักตัว ผู้รับจ้างมีหน้าที่นำพนักงานมาตรวจหาเชื้อ COVID-19 โดยวิธี ATK กับ ปตท. ตามวันและเวลาที่แจ้งความจำนงไว้กับ ปตท. ทั้งนี้ผู้รับจ้างมีหน้าที่จัดหาชุดตรวจ ATK มาเอง และ ชุดตรวจ ATK ต้องผ่านการอนุญาตจากหน่วยงานรัฐที่เกี่ยวข้องแล้ว

กรณีที่ 2 พนักงานของผู้เสนอราคา**อยู่ในจังหวัดตามสถานที่ตั้งของหน่วยงาน ปตท.** ที่ผู้เสนอราคาจะเข้ามาปฏิบัติงาน

พนักงานของผู้รับจ้างจะต้องส่งบันทึกกิจกรรมย้อนหลัง 14 วัน ในวันที่ตรวจหาเชื้อโดยวิธี ATK เพื่อให้ ปตท. ตรวจสอบว่าไม่มีประวัติเดินทางไปยังพื้นที่เสี่ยง

- ผู้รับจ้างมีหน้าที่แจ้งความจำนงเพื่อเข้าตรวจหาเชื้อ COVID-19 โดยวิธี Anti-gen test KIT (ATK) กับ ปตท. ก่อนหรือในวันที่เข้าปฏิบัติงาน โดยจะต้องจองวันตรวจในระบบของ ปตท. ล่วงหน้าอย่างน้อย 2 วัน
- ผู้รับจ้างมีหน้าที่นำพนักงานมาตรวจหาเชื้อ COVID-19 โดยวิธี ATK กับ ปตท. ตามวันและเวลาที่แจ้งความจำนงไว้กับ ปตท. ทั้งนี้ผู้รับจ้างมีหน้าที่จัดหาชุดตรวจ ATK มาเอง และ ชุดตรวจ ATK ต้องผ่านการอนุญาตจากหน่วยงานรัฐที่เกี่ยวข้องแล้ว

2.2. ผู้รับจ้างมีหน้าที่กรอกข้อมูล รูป ชื่อ นามสกุล และที่พัก และอื่น ๆ ตามแบบฟอร์มที่ ปตท. กำหนด

2.3. เมื่อดำเนินการขั้นตอนที่ (2.1) และ (2.2) ครบถ้วน และผลตรวจออกมาว่า “ไม่ติดเชื้อ” ปตท. จะพิจารณาออกบัตร COVID-19 Pass ให้ต่อไป

2.4. บัตร COVID-19 Pass มีอายุ 1 เดือน นับถัดจากวันที่ออกบัตร

3. มาตรการทั่วไปที่ต้องปฏิบัติอย่างเคร่งครัดระหว่างการปฏิบัติงานที่ ปตท.

3.1. ผู้รับจ้างมีหน้าที่กำกับดูแล และสนับสนุนทรัพยากรเพื่อให้พนักงานของผู้รับจ้าง ปฏิบัติตามมาตรการควบคุมโรค COVID-19 ที่ทางหน่วยงานราชการและ ปตท. กำหนดอย่างเคร่งคัด

3.2. หาก ปตท. ตรวจพบการไม่ปฏิบัติตามมาตรการ จะขอดำเนินการออกหนังสือตักเตือน

3.2.1. หาก ปตท. ตรวจพบการไม่ปฏิบัติตามมาตรการ และออกหนังสือตักเตือนเป็นครั้งที่ 3 ปตท. ขอสงวนสิทธิพิจารณาหยุดงาน และบอกเลิกสัญญาโดยไม่จ่ายเงิน

3.3 ก่อนเข้าดำเนินการในวันแรก ผู้รับจ้างจะต้องแจ้งความประสงค์ และนำพนักงานที่จะเข้าปฏิบัติงานในพื้นที่ของ ปตท. มารับฟังการสื่อความเรื่องการปฏิบัติตามมาตรการควบคุมโรค COVID-19

3.4 ทุกวันตลอดการทำงานที่ ปตท. ผู้รับจ้างมีหน้าที่รายงาน สุขภาพ พฤติกรรม ความเสี่ยงต่อการติดเชื้อ COVID-19 ของพนักงานจากบริษัทผู้รับจ้าง

3.5 ให้พนักงานของผู้รับจ้าง รายงานตัวกับ อสม. พื้นที่ที่พักอาศัย ในวันแรกที่เข้าปฏิบัติงาน

3.6 ผู้รับจ้างมีหน้าที่สุ่มตรวจหาเชื้อ COVID-19 กับพนักงาน เป็นประจำทุกอาทิตย์ ไม่ซ้ำคน อาทิตย์ละ 25% ของจำนวนพนักงานที่เข้าปฏิบัติงานทั้งหมด และส่งผลตรวจให้กับ ปตท.

3.7 กรณีพนักงานของผู้รับเหมาไม่เข้าทำงานที่ ปตท. เกิน 7 วัน ถือว่า COVID-19 Pass หมดอายุ

3.8 กรณีพบรายงานพนักงานของผู้รับจ้างเป็นผู้ติดเชื้อ หรือสัมผัสผู้ติดเชื้อ ปตท. ขอสงวนสิทธิสั่งหยุดงาน และเข้าสู่กระบวนการสอบสวนโรคของ ปตท. ทันที ทั้งนี้พนักงานที่ไม่เกี่ยวข้อง ทาง ปตท. จะพิจารณาให้ดำเนินการต่อได้

4. มาตรการระหว่างกักตัวก่อนเข้าปฏิบัติงาน ณ สถานที่ตั้งของหน่วยงาน ปตท. ที่ผู้รับจ้างจะเข้ามาปฏิบัติงาน

4.1. เข้าพักในโรงแรมหรือสถานที่ที่ ปตท. กำหนด ซึ่งเป็นไปตามมติของ คณะกรรมการโรคติดต่อจังหวัดระยอง

4.2. ห้ามออกนอกเขตโรงแรมหรือสถานที่ที่ ปตท. กำหนด โดยหากจำเป็นต้องออกจากโรงแรมหรือสถานที่ที่ ปตท. กำหนด ต้องขออนุญาตเป็นลายลักษณ์อักษรจากผู้ควบคุมงาน ปตท. ยกเว้นกรณีมีเหตุจำเป็นเร่งด่วน เช่น เหตุผลด้านสุขภาพ ความปลอดภัย ขอให้ดำเนินการแจ้งหัวหน้างาน หรือผู้ควบคุมงาน ปตท. ผ่านช่องทางการสื่อสารต่าง ๆ และรายงาน Timeline ของตนหลังผ่านพ้นเหตุการณ์ภายใน 1 วัน

4.3. ผู้กักตัวต้องอยู่ภายในห้องพักของตัวเอง ห้ามรวมกลุ่ม รวมกลุ่มทานอาหาร/สังสรรค์ หรือ เข้าไปอยู่รวมกันในห้องใดห้องหนึ่ง โดยหากจำเป็นต้องรวมกลุ่มประชุมหรือปรึกษางาน ต้องรวมกลุ่มในพื้นที่ที่ ปตท. กำหนดและเป็นไปมาตรการ social distance

4.4. ผู้กักตัวต้องรักษาระยะห่างระหว่างบุคคล 1 - 2 เมตร อย่างเคร่งครัด

4.5. ผู้กักตัวต้องไม่ใช้ของใช้ส่วนตัว เช่น ผ้าเช็ดหน้า ผ้าเช็ดตัว แก้วน้ำ หลอดดูดน้ำ ร่วมกับผู้อื่น

4.6. ใส่หน้ากากอนามัยตลอดเวลาเมื่อออกนอกจากที่พัก

4.7. รับประทานอาหารที่ปรุงสุก ไม่ใช้ภาชนะหรือรับประทานอาหารร่วมกับผู้อื่น

4.8. หากจำเป็นต้องติดต่อกับบุคคลภายนอกให้ทำการติดต่อในพื้นที่ที่ ปตท. กำหนดหรือ Lobby โรงแรม โดยในการติดต่อต้องเป็นไปมาตรการ social distance และแจ้งผู้ควบคุมงาน ปตท. ทุกครั้ง

4.9. ปฏิบัติตามหลักการของภาครัฐ DMHTTA (Distance-Mask-Hand-Test: Thermal scan-Test: Covid Test-Application: หมอชนะ)

4.10. ปตท. จะส่งเจ้าหน้าที่เฝ้าระวังเพื่อทำงานร่วมกับพนักงานรักษาความปลอดภัยของโรงแรม หรือพนักงานรักษาความปลอดภัยในที่พักที่ ปตท. กำหนด

4.11. ปตท. และเจ้าหน้าที่สาธารณสุขจะร่วมกันทำการสุ่มตรวจ ณ. ที่พัก

4.12. ให้ความร่วมมือและปฏิบัติตามคำแนะนำของเจ้าหน้าที่และผู้ควบคุมงาน ปตท.

4.13. จัดส่งแบบคัดกรองวัดอุณหภูมิและบันทึกกิจกรรมที่ลงนามโดยหัวหน้าทีม ให้ผู้ควบคุมงาน ปตท. ทุกวัน

4.14. ทำการเปิด GPS tracking timeline บน Application Google map บนโทรศัพท์มือถือ เพื่อให้สามารถตรวจสอบการเดินทางย้อนหลังได้

4.15. หากมีอุณหภูมิร่างกายสูงกว่า 37.5 องศาเซลเซียส ต้องรีบแจ้งผู้ควบคุมงาน ปตท. ทันที

4.16. ตรวจหาเชื้อ Covid19 โดยวิธีการ RT-PCR และแจ้งผลแก่ผู้ควบคุมงาน ปตท. ก่อนเข้าปฏิบัติงานในพื้นที่โรงแยกก๊าซธรรมชาติ

4.17. มาตรการข้างต้นสามารถเปลี่ยนแปลงได้โดยอ้างอิงตามมาตรการที่ประกาศโดยราชการ หรือตามมติจากที่ประชุม GSP-EMC ของโรงแยกก๊าซธรรมชาติระยอง

5. มาตรการระหว่างเข้าปฏิบัติงาน ณ สถานที่ตั้งของหน่วยงาน ปตท. ที่ผู้รับจ้างจะเข้ามาปฏิบัติงาน

5.1. แรงงานจากต่างพื้นที่พักในโรงแรมหรือสถานที่ที่ ปตท. กำหนด ซึ่งเป็นไปตามมติของ คณะกรรมการโรคติดต่อระยอง โดยไม่มีการเปลี่ยนที่พัก

5.2. หลังเลิกงานอยู่ภายในที่พักของตัวเอง ห้ามรวมกลุ่ม โดยหากจำเป็นต้องรวมกลุ่มประชุมหรือปรึกษางานต้องรวมกลุ่มในพื้นที่โล่งและเป็นไปมาตรการ social distance

5.3. เดินทางจากที่พักมาที่โรงแยกก๊าซธรรมชาติโดยตรง หลีกเลี่ยงการออกนอกเส้นทาง ทั้งขาไปและขากลับโดยรถรับส่งที่ใช้ต้องปฏิบัติตามมาตรการ Social Distance

5.4. ห้ามไปในสถานที่ที่มีผู้คนพลุกพล่าน สถานที่ที่มีการรวมกลุ่มคน

5.5. ผู้ปฏิบัติงานต้องรักษาระยะห่างระหว่างบุคคล 1 - 2 เมตร อย่างเคร่งครัด

5.6. ผู้ปฏิบัติงานต้องไม่ใช้ของใช้ส่วนตัว เช่น ผ้าเช็ดหน้า ผ้าเช็ดตัว แก้วน้ำ หลอดดูดน้ำ ร่วมกับผู้อื่น

5.7. ใส่หน้ากากอนามัยตลอดเวลาเมื่อออกนอกจากที่พัก

5.8. การรับประทานอาหารในร้านอาหารจะต้องระมัดระวัง และปฏิบัติตามมาตรการ Social Distance

5.9. รับประทานอาหารที่ปรุงสุก ไม่ใช้ภาชนะหรือรับประทานอาหารร่วมกับผู้อื่น

5.10. ปฏิบัติตามข้อกำหนดการเข้าปฏิบัติงานของโรงแยกก๊าซ และสวมใส่ PPE ตามลักษณะงานอย่างถูกต้อง

5.11. ปฏิบัติตามหลักการของภาครัฐ DMHTTA (Distance-Mask-Hand-Test: Thermal scan-Test: Covid Test-Application: หมอชนะ)

5.12. ให้ความร่วมมือและปฏิบัติตามคำแนะนำของเจ้าหน้าที่และผู้ควบคุมงาน ปตท.

5.13. จัดส่งแบบคัดกรองวัดอุณหภูมิและบันทึกกิจกรรมที่ลงนามโดยหัวหน้าทีม ให้ผู้ควบคุมงาน ปตท. ทุกวัน

5.14. ทำการเปิด GPS tracking timeline บน Application Google map บนโทรศัพท์มือถือ เพื่อให้สามารถตรวจสอบการเดินทางย้อนหลังได้

5.15. หากมีอุณหภูมิร่างกายสูงกว่า 37.5 องศาเซลเซียส ต้องรีบแจ้งผู้ควบคุมงาน ปตท. ทันที

5.16. มาตรการข้างต้นสามารถเปลี่ยนแปลงได้โดยอ้างอิงตามมาตรการที่ประกาศโดยราชการ หรือตามมติจากที่ประชุม GSP-EMC ของโรงแยกก๊าซธรรมชาติระยอง

6. มาตรการการปฏิบัติตนสำหรับผู้รับจ้าง ในช่วงนอกเวลาทำงาน

6.1. ช่วงเวลาระหว่างเดินทางไป-กลับระหว่างโรงงานกับที่พักต้องปฏิบัติดังนี้

6.1.1. ต้องเดินทางโดยรถที่ทางบริษัทฯ จัดให้เท่านั้น

6.1.2. ห้ามแวะระหว่างทาง เมื่อถึงที่พักต้องเข้าห้องทันที

6.1.3. สวมหน้ากากอนามัยตลอดการเดินทาง

6.1.4. มีฉากกั้นระหว่างบุคคล

6.1.5. ล้างเจลแอลกอฮอล์ก่อนขึ้นรถ

6.1.6. พ่นฆ่าเชื้อรถโดยสารทุกวัน

6.1.7. ระบุที่นั่ง ห้ามนั่งสลับที่ (ต้องนั่งรถคันเดิมเท่านั้น)

6.1.8. ต้องมีการวัดอุณหภูมิร่างกายก่อนขึ้นรถ

6.1.9. จัดทำทะเบียนรายชื่อผู้โดยสารในแต่ละรอบ และทุกวัน

6.2. ช่วงเวลาระหว่างพักในที่พักต้องปฏิบัติดังนี้

6.2.1. กรณี ผู้รับเหมา มาจากจังหวัดสีแดงต้องได้รับอนุมัติจาก สสจ. ระยอง

6.2.2. กรณี ผู้รับเหมา มาจากระยอง ที่พักของผู้รับเหมาจะต้องได้รับการอนุมัติจาก ปตท.

6.2.3. ต้องรายงานเวลาเข้า-ออกที่พัก และเข้า-ออกโรงงาน ให้กับ รปภ. หรือตัวแทนบริษัท และ ปตท.

6.2.4. ห้ามมั่วสุม ห้ามสลับห้อง อยู่แต่ห้องของตนเอง

6.2.5. บริษัทฯ บริการจัดหา อาหารและเครื่องดื่มให้พนักงานครบทั้งสามมื้อ

6.2.6. บริษัทฯ จัดหา รปภ. หรือตัวแทนบริษัทเพื่อกำกับดูแลการปฏิบัติตามมาตรการนี้อย่างเคร่งครัด

6.2.7. ห้ามมิให้พบปะคนนอก และห้ามบุคคลภายนอกเข้าพบโดยเด็ดขาด

6.2.8. ห้ามมิให้นำพนักงานกลุ่มอื่น ๆ ของบริษัท หรือ พนักงานที่อาจจะจ้างใหม่มาพบปะ พูดคุยกับพนักงานกลุ่มปฏิบัติงาน ณ สถานที่ตั้งของหน่วยงาน ปตท.

6.2.9. หากมีการเปลี่ยนแปลงผู้รับเหมา ต้องแจ้งให้กับ ปตท. อนุมัติก่อนทุกครั้ง

6.2.10. ห้ามใช้ของใช้ร่วมกับผู้อื่น

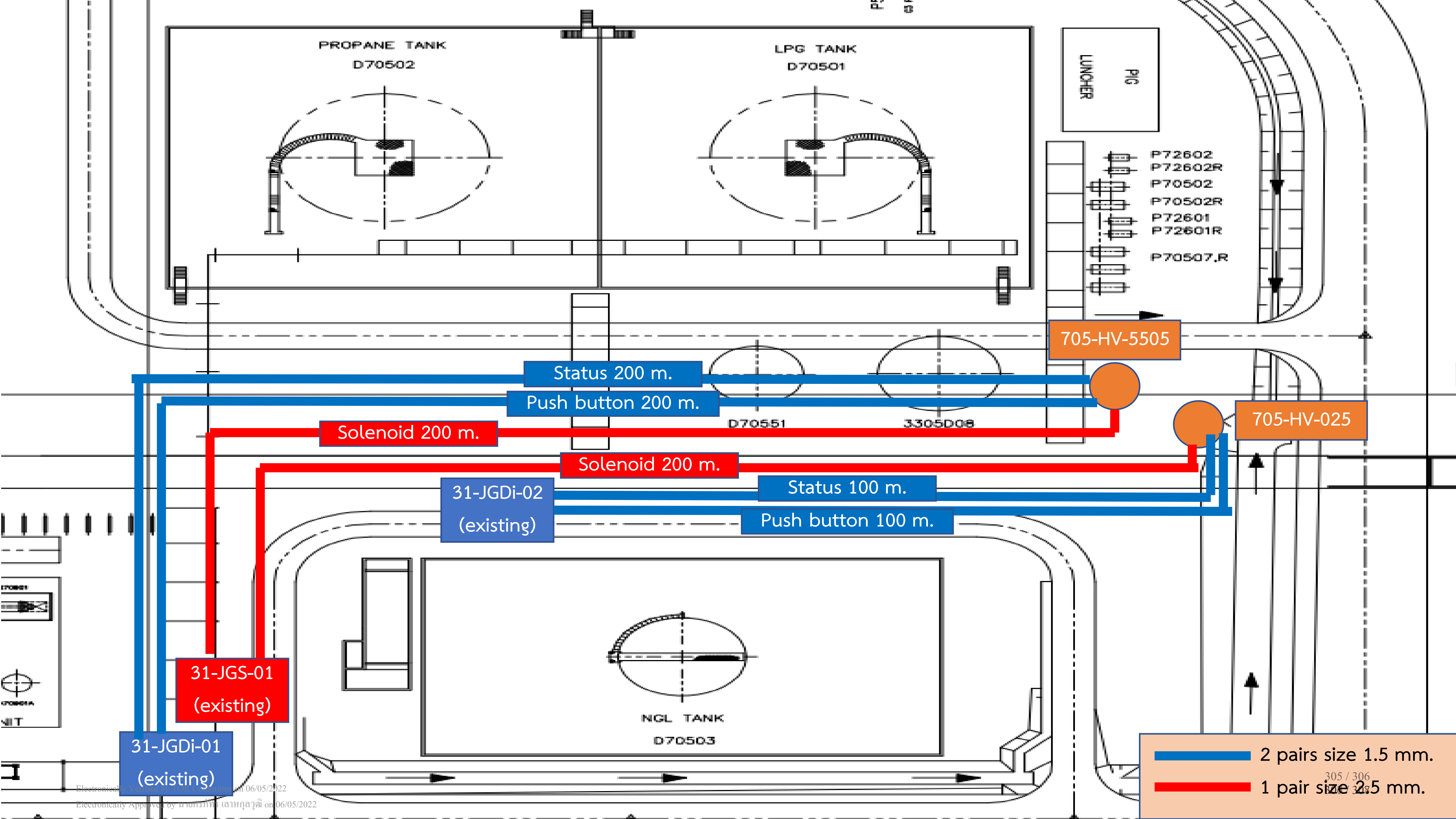
6.2.11. เมื่อถึงที่พักต้องล้างมือก่อนทุกครั้ง และเปลี่ยนเสื้อ อาบน้ำ ให้เรียบร้อยทันที

6.2.12. ห้ามนำพนักงานกลุ่มอื่น ที่ยังไม่ได้ทำการตรวจเชื้อ COVID-19 มาปะปนกับพนักงานกลุ่มที่ตรวจเชื้อแล้วมีผลเป็นลบ

6.2.13. พิจารณาจัดที่พักให้พนักงานเป็น Zone เดียวกัน เพื่อป้องกันการปะปนกับประชาชนทั่วไป

6.2.14. กรณีพักเป็นกลุ่ม เช่น ตึก อพาร์ทเม้นต์ ให้จัดทำแผนผังห้องพักและตึกที่พัก

7. ปตท. สงวนสิทธิ์ในการเปลี่ยนแปลงมาตรการให้มีความเหมาะสม รัดกุม สอดคล้องกับข้อกำหนดของทางราชการตามสถานการณ์การแพร่ระบาดของโควิด-19 ที่อาจจะมีการเปลี่ยนแปลงไปในอนาคต


PROPANE TANK
D70502
LPG TANK
D70501
PIG
LUNCHER
P72602
P72602R
P70502
P70502R
P72601
P72601R
P70507,R
705-HV-5505
Status 200 m.
Push button 200 m.
D70551
3305D08
705-HV-025
Solenoid 200 m.
Solenoid 200 m.
31-JGDi-02
(existing)
Status 100 m.
Push button 100 m.
31-JGS-01
(existing)
NGL TANK
D70503
31-JGDi-01
(existing)
2 pairs size 1.5 mm.
1 pair size 2.5 mm.

<u>BOM ใบเสนอราคา</u>

Item	รายการ	Specification	จำนวน	หน่วย	ราคา
1	Instrument cable	single core x 1.5 mm.	100	เมตร	
2	Instrument cable	2 pairs x 1.5 mm.	700	เมตร	
3	Instrument cable	1 pair x 2.5 mm.	400	เมตร	
4	Cable gland	Ex d, Material: Brass, with Shround	1	SET	
5	Limit switch	Proximitor, Ex d	2	ตัว	
6	Pressure Switch	Ex d	1	ตัว	
7	Solenoid valve	JBEF8327G042MS 24VDC, Ex d	2	ตัว	
8	Push button switch box	แบบ OPEN (ปุ่มสีแดง) และ CLOSE (ปุ่มสีเขียว) Specification ขั้นต่ำเป็น Ex d ทั้งหมด	14	box	
9	อุปกรณ์อื่น ๆ ที่จำเป็นต่อการติดตั้งภายในระบบ		1	SET	
10	Engineering & Installation		1	งาน	