

**SHELL PETROLEUM DEVELOPMENT COMPANY OF NIGERIA LIMITED**

**CORROSION UNDER INSULATION (CUI)**

**INSPECTION STRATEGY FOR GBARAN CPF**

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7. **INTRODUCTION**

**Corrosion Under Insulation (CUI)** in simplest term is any type of corrosion that occurs due to moisture present on the external surface of insulated equipment. It is one of the most dangerous degradation mechanisms in plant and topside facilities. This deterioration is hazardous because it is unseen and difficult to detect without proper assessment. Studies have shown that 40% to 60% of piping maintenance costs are from CUI related activities, which can often amount to 10% of a company’s total maintenance budget. The damage/attack can be caused by one of multiple factors, and can occur in equipment operating at ambient, low, and heated services, depending upon conditions. Also, CUI can occur on thermally insulated equipment that is in service, out of service, or in cyclic service. Because these surfaces are not generally available/accessible for visual examination, the onset of corrosion cannot be easily identified, and in extreme cases, severe corrosion with consequential impairment of system integrity can occur.

Although, effective protective coatings and weather barriers can help minimize the potential for CUI; however, coatings and insulation under cladding deteriorate over time. External maintenance alone is not a feasible solution without a well thought out inspection strategy. Adopting a risk-based approach to CUI is considered the best solution.

This document aims to develop practical inspection and maintenance strategies to minimize risk and maintenance costs of insulated equipment in Gbaran CPF.

1. **OBJECTIVES**

The objective of this CUI inspection strategy document is to outline the technical requirements to support the inspection and maintenance of insulation systems installed on the Gbaran Central Processing Facility,

1. **OVERVIEW OF CUI DAMAGE MECHANISM**

CUI is corrosion resulting from the ingress of water and contaminants through breaks in the cladding or jacketing. Water may come from numerous sources such as rainwater, a deluge system, process spillage, or condensation in humid environments which is then trapped under insulation. CUI damage in carbon and low alloy steels is characterized by either general metal wastage or pitting due to the localized breakdown of passivity. CUI damage in austenitic and duplex stainless steels is a form of pitting and Chloride Stress Corrosion Cracking (CSCC).

**3.1 Managing CUI**

There are several approaches to managing CUI:

• Strip and repaint the equipment;

• Manage the leaks as they occur;

• Adopt a risk-based approach and carry out a targeted inspection program.

The process of stripping and repainting the asset whilst managing leaks is reactive and dangerous, especially where hydrocarbons are concerned. A risk based approach is therefore the best solution to be able to direct resources to the highest risk assets at the right time. This is the approach we are adopting for Gbaran CPF.

1. **SUSCEPTIBLE AREAS FOR CUI**

The following identified locations are typical area where wet insulation, the accumulation of moisture and, subsequently, corrosion can be found.

* **Insulated Piping**

For insulated piping, inspect:

* at the bottom of the lower elbow on a vertical line.
* at the bottom or near tees for branch lines.
* at the bottom or near horizontal piping where instruments or pipe hanger supports protrude through the insulation system
* at the bottom of horizontal lines where water or rust stains on the circumferential seams of the jacketing indicate that moisture had leached out from the wet insulation.
* above valves and flanges on vertical lines.
* any location where the degree of difficulty in applying insulation on pipe and equipment is high and therefore, failure is predictable.
* **Insulated Vessels and Tanks**

For insulated vessels and tanks, inspect:

* on vertical vessels and tanks, above the intermediate insulation support rings
* around the base of the tank, at the base plate, orienting the inspection 90 degrees apart
* near large vessel and tank nozzles and manholes, especially where the insulation jacket has visibly shifted from the nozzle.
* at the bottom of horizontal tanks where water or rust stains on the circumferential seams of the jacketing indicate that moisture had leached out from the insulation.
* under protruding vessel nameplates.

1. **CUI MITIGATION STRATEGY**

This strategy covers unit level prioritization, generation of CUI register, challenging the need for insulation, initial inspection and data validation, production of detailed risk assessments, and the development of inspection plans.

**5.1 WORK FLOW FOR CUI MITIGATION STRATEGY**

**STEP 1:** **UNIT LEVEL PRIORITIZATION**

(Identify equipment prone to CUI)

**STEP 2**: **DEVELOP A CUI REGISTER**

(Generate a list of CUI susceptible equipment / piping & populate the register with Material of construction, operating profile, insulation type, environ. Factors, etc.)

**STEP 3**: **CHALLENGE THE NEED FOR INSULATION**

**STEP 4**: **INITIAL INSPECTION & DATA VALIDATION**

(Conduct initial visual inspection & collect other data need for probability assessment.)

**STEP 5**: **DETAILED RISK ASSESSMENT**

(Carryout probability and consequence assessment of each equipment or piping circuit using CCAM tool in IMS.)

**STEP 6**: **DEVELOP INSPECTION STRATEGY/INSPECTION PLANNING**

(Plot each equipment/piping on the CUI strategy matrix to determine strategy/interval)

**STEP 7**: **INSPECTION EXECUTION**

(Visual and NDT examination of suspected or damaged point and restoration of insulation system)

**STEP 8**: **CAPTURE INSPECTION RECORD IN IMS**

(Capture data, recommendation, turn schedule, update CMF and analysis in IMS)

**STEP 1: UNIT LEVEL PRIORITIZATION**

Not all the insulated equipment and piping are susceptible to CUI. So the first step in any CUI inspection is identifying the potential equipment. Points considered at this stage are the material of construction and operating temperature of equipment:

* **Material of the equipment**

In the case of insulated Carbon Steel (CS) equipment, trapped water along with contaminants act as an electrolyte on the surface. As a result general corrosion occurs on equipment surface which slowly lead to the failure of equipment if remained unattended.

 In the case of Austenitic and duplex stainless steel, CUI occurs in the form of SCC (Stress Corrosion Cracking) due to increased chlorine concentration.

* **Operating temperature of equipment**

Insulation makes a closed environment on metal surface and can saturates the air trapped inside insulation. Since equipment works in cyclic temperature range, there exists a temperature range under which CUI happens.

 API 571 RP 2015 - Damage mechanisms affecting refinery equipment gives the temperature range of CUI as

* 10°F (–12°C) and 350°F (175°C) for carbon and low alloy steels,
* 140ºF (60°C) and 400ºF (205°C) for austenitic stainless steels and duplex stainless steels

In the first step, equipment is classified as per material of construction while in this phase, the equipment is further classified with respect to the risk they carry as a result of the corresponding exposure to temperature range. As shown in Table 1, carbon steel equipment with an operating temperature range of 490C to 930C are susceptible to CUI with most severe environment and are classified under the high-risk category. Equipment working in cyclic temperature range and equipment which are down for long time demand special attention.

The CUI risk categories according to Shell DEP 30.46.00.31-Gen. February 2017 for carbon steel in Table 1 and Environmental Stress Corrosion Cracking (ESCC) risk for stainless steel in Table 2 shall be followed for unit prioritization

Table 1: CUI Risk Categories for carbon steel

|  |  |
| --- | --- |
| Operating temperature | CUI Risk |
| < -5oC | Low |
| > 175oC | Low |
| -5oC to 49oC | Medium |
| 50oC to 175oC | High |
| Cycling temperatures between -20oC and 320oC | Extreme |

Table 2: ESCC Risk Categories for stainless steel

|  |  |
| --- | --- |
| Operating temperature | CUI Risk |
| < 50oC | Low |
| 50oC to 175oC | High |
| > 175oC | Low |

**STEP 2: DEVELOP A CUI REGISTER**

This step involves using Process Engineering Flow Scheme (PEFs) to identify all the insulated equipment and piping that are susceptible to CUI in line with step 1. The register will contain list of insulated equipment, material of construction, coating/insulation type, drawing number, line description, operating profile, environmental factors and process fluid. The condition and appearance of the insulation will also be stated in the register after initial field inspection.

**STEP 3: CHALLENGE THE NEED FOR INSULATION**

After the list of CUI-susceptible equipment and piping list has been developed, the need for insulation should be verified. Insulation systems are provided for heat conservation, process requirement, personal protection and noise reduction. Insulation for personal safety is applicable where exposed surface temperatures exceed 65oC in normal or short term operating conditions. Therefore, the purpose of the insulation on equipment and piping should be well understood before performing CUI inspections. This can help establish priorities, determine what hazards may exist, determine if insulation can be removed while equipment/lines are in operation, and determine if insulation can be permanently removed. In fact, one of the big benefits from this insulation evaluation process is the possible realization and identification of equipment areas that do not require insulation to function effectively thereby removing the use of insulation will lead to a 100% elimination of CUI risks.

A management of change (MOC) process shall be employed when considering modification or removal of any insulation in the facility.

Assets/facilities may use the flow scheme shown in Appendix 1 Figure 1 of MEC\_RP\_04-06.1\_v1 to determine if insulation is required. Equipment and piping that has been de-insulated/de-lagged or has had an alternative applied (e.g. insulative paint or weather shield) should be removed from the CUI risk management programme.

**STEP 4: INITIAL INSPECTION AND DATA VALIDATION**

 The ISO drawing is required for this initial inspection in other to validate the insulated lines in the CUI register, to identify the suspect points on the drawing as well as the condition/appearance of the insulation. The Suspect Points are typically locations on piping or equipment circuits susceptible to CUI and they will be the CMLs for CUI Inspections. All Suspect Points must be identified on ISOs. It is role of the Initial Inspections to identifying and quantifying on ISOs all Damaged Insulation Locations (Damaged Points). Following the external visual inspection of susceptible systems, additional examination is required for the inspection of CUI. The extent and type of the additional CUI inspection shall be determine as scope (extent and frequency). A recognized approach to determine the Extent of CUI Inspection following Visual Inspection for Susceptible Piping and Equipment is doing a Risk Based Inspection Assessment (CCAM).   After determining the Inspection Extent for CUI, it must identify the Suspect Points and Damaged Points that will be inspected in detail.

Considerations for selection of the Suspect Points and Damaged Points sample that will be inspected include but are not limited to: history of CUI for the specific assets or comparable ones; visual condition of the external covering and insulation; rust stains, biological growth and bulged weather jacketing; evidence of fluid leakage; whether the piping systems are in intermittent service; condition/age of the external coating, if known; evidence of areas with wet insulation; potential for the type of insulation to absorb/hold more water; low points of sagging lines; bottom of vertical pipe; proximity to equipment that could increase the local humidity; areas where temperature regimes are moving into and out of the CUI temperature range (cycling services).

**STEP 5: DETAILED RISK ASSESSMENT (CCAM)**

To consistently prioritise CUI scope across all assets/facilities, a consequence assessment tool has been developed. This tool, the CCAM (CUI Consequence Assessment Model), is the approved tool to estimate the consequence of a CUI leak and is in the IMS software. For equipment and piping remaining in the CUI risk management programme, the potential consequence from a failure should be determined using the CCAM with a failure mode of a 12.5mm [½”] diameter hole. People, Assets, Environment and Community consequences should be determined individually with the highest consequence level governing. When assessing RAM asset consequence, include only direct damage to assets; do not include Consequential Business Loss (CBL). Based on the risk based assessment outcomes, we develop inspection activities and strategies for the asset. The outcome of CCAM assessment will help to prioritize and determine extent of CUI inspection .We then identify the locations that are most susceptible to CUI (suspect points) and damaged points that will be inspected in detail. This will help to develop a targeted inspection plan. When the outcome of assessment is Priority 1 Red, it require inspection of CUI according to RBI mandatory schedule. The remaining items become Priority 2, with Risk based inspection. The CCAM tool is mainly applicable carbon steel surfaces under insulation with corrosion by localized pitting and uniform corrosion.

**STEP 6: INSPECTION PLANNING**

The next activity should be planning the Inspection Execution. This process involves preparation of work pack to capture the scope of inspection as well as the technique to be deployed. Inspection should be carried out at suspected and damaged points. The risk based approach will be to determine areas with wet insulation using infra- red thermography in other to have a focused inspection. Pulse Eddy current technique can then be deployed for inspection of CUI at areas with wet insulation, suspect points as well as damaged points. The extent of inspection is necessary for planning, which includes length of insulation to be inspected, number and nature of CMLs to be inspected. As per API 570, if external coverings are in good condition and there is no reason to suspect damage behind them, it is not necessary to remove them for inspection of the equipment. But CUI damage is often quite insidious in that it can occur in areas where it seems unlikely. So it is always advisable to remove some insulation from the most critical areas as a part of CUI inspection. However, insulation removal can be done on areas where PEC inspection discovers CUI or areas with wet insulation as shown by thermal imaging. Pulsed Eddy Current (PEC) may be deployed without removal of insulation on both equipment & piping and average metal wall thickness of the location below the insulation can be measured. Long Range Ultrasonic Testing (LRUT) can also be used for piping inspection where operating temperature is less than 125 Deg C. A small band of insulation needs to be removed for mounting array of UT transducers band in LRUT technique. It scans the piping longitudinally on both sides of transducer ring using guided ultrasonic waves. This technique gives the cross-sectional metal loss of piping although it is suitable for long straight length of pipe. Priority for PEC inspection will be given to insulated piping and equipment that falls within priority 1.

**STEP 7: INSPECTION EXECUTION**

The next step is “Inspection Execution”. Once all support activities are concluded, the next step is to carryout visual and NDE examination on all the selected CMLs and all collected data shall be documented and recorded (reports, figures, diagrams, Inspection recommendations) in IMS software. Inspection strategy that have a RBI Program well developed shall feedback into IMS software and studies with the inspection results in order to refine the further Inspection Scope and Analysis. Pulse Eddy Current technique will be used to determine presence of CUI at suspected, damaged and wet spots in the insulation. Infra-red thermography or neutron back scatter technique will be used to determine spots with wet insulation. This can be done preferably in wet season to ensure optimal result.

Further action can be taken after accessing the condition of metal surface exposed by the above guidelines. If the metal surface is found to be in good condition there is no need for further removal of insulation. But if there is indication of CUI, inspector should access the extent of CUI damage and if necessary, action to be taken for extensive removal of insulation.

The following general steps can be followed to determine the extent of insulation removal for direct inspection of CUI of any insulated equipment:

* Remove all the inspection windows to access the condition of the surface under the window. Special consideration to be given on the condition of the coating under insulation. If the coating under the inspection window is good then it is an indication of less CUI in the system.
* If there is indication of coating damage or starting of general corrosion under inspection window some insulation can be removed from the most critical areas
* As a general practice for piping, insulation is opened at the support locations and at elbows, tees and every ten meters interval if operating temperature is below 150 0C. If operating temperature is above 150 0C insulation pockets are removed for ultrasonic thickness gauging.

Similarly for Columns / vessels / heat exchangers;

* Insulation is opened at the top dish and at insulation support rings in top zone in CUI prone zone.
* Insulation is removed from top shell up to operating temperatures 150 0C
* In all the vertical columns and vessels, insulation is opened at the nozzles/ manways and at sample Pockets for UT (Ultrasonic thickness) measurements
* In horizontal vessels, insulation is removed at sample areas where detachment is seen.

**STEP 8: RESTORE INSULATION & CAPTURE INSPECTION RECORDS IN IMS**

After inspection execution, the final step is to restore insulation and capture inspection result in IMS. All the removed cladding has to be reinstalled after execution of all the recommendation. Ensure quality control of coating and services during reinstallation of insulation. All the inspection results need to be uploaded in IMS for further analysis.

1. **CUI MITIGATION STRATEGY FOR GBARAN CPF**

The insulated lines in Gbaran CPF will be subjected to the eight steps above. However, out of a total of 271 insulated lines identified in Gbaran CPF, the following were found to be highly susceptible to water ingress and CUI owing to the condition of the insulation system as at the time of initial field inspection. Their condition includes caulking deterioration, process/corrosion stains, improperly lapped jacketing seam, thorn/pierce jacketing, improperly sealed vent, and instrument protrusion, etc. Insulation for personnel protection have 26 lines that the purpose for insulation need to be challenged and requires PEC inspection. Those for heat conservation are eight (8), the acoustic insulation are five (5) while those for passive fire proofing are fourteen (14) in number. The 36 stainless steel and duplex stainless steel lines which are classified as CCAM priority 2 will be assessed using RBI methodology.

It is worthy to note that any change from initial design of the facility must pass through Shell Management of Change (MoC) process to secure approval from responsible technical authorities before implementation.

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| **MODULES** | **PIPING TAGS NOS.** | **INSULATION TYPE** | **EQUIPMENT TYPE** | **MATERIAL OF CONSTR.** | **INSPECTION PLAN** |
| Glycol Regeneration system TR1 Glycol Pumps | 6''-C41120-11420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR1 Glycol Pumps | 6''-C41121-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR1 Glycol Pumps | 6''-C41122-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR1 Glycol Pumps | 3''-C41124-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR1 Glycol Pumps | 3''-C41123-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR1 Glycol Pumps | 3''-C41129-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR1 Glycol Pumps | 2''-C41108-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR1 Glycol Pumps | 3''-C41130-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 REBOILER | 2''-D41201-11460 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 FLASH DRUM | 2''-D41206-11460 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 FLASH DRUM | 2''-D41207-11460 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 FLASH DRUM | 2''-D41208-11460 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 FLASH DRUM | 2''-D41209-11460 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 FLASH DRUM | 2''-D41204-11460 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 FLASH DRUM | 2''-D41213-11460 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 2''-B41208-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 6''-C41218-11420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 6''-C41219-11420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 6''-C41220-11420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 6''-C41222-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 6''-C41221-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 3''-C41223-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 3''-C41229-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 3''-C41230-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 3''-C41224-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |
| Glycol Regeneration system TR2 Glycol Pumps | 2''-C41225-91420 | P | Piping | CS | Carry out PEC Inspection at Suspected Points to ascertain baseline information & coat piping with insulating paints e.g Mascoat. |

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| **MODULES** | **PIPING TAGS NOS.** | **INSULATION TYPE** | **EQUIPMENT TYPE** | **MATERIAL OF CONSTR.** | **Inspection Plan/Mitigation plan** |
| Glycol Regeneration system TR1 Glycol Pumps | 3''-C41131-91420 | H | Piping | CS | INFRARED THERMOGRAPHY, PEC @ CML & replacement of thorn Jacket |
| Glycol Regeneration system TR1 Glycol Pumps | 3''-C41134-91420 | H | Piping | CS | INFRARED THERMOGRAPHY, PEC @ CML & replacement of thorn Jacket |
| Glycol Regeneration system TR2 REBOILER | 4''-C41216-11461 | H | Piping | CS | INFRARED THERMOGRAPHY, PEC @ CML & proper sealing of valve or instrument protrusion |
| Glycol Regeneration system TR2 FLASH DRUM | 3''-C41203-11420 | H | Piping | CS | INFRARED THERMOGRAPHY, PEC @ CML & proper sealing of insulation end cap |
| Glycol Regeneration system TR2 FLASH DRUM | 3''-C41210-11420 | H | Piping | CS | INFRARED THERMOGRAPHY, PEC @ CML & proper sealing of insulation plug |
| Glycol Regeneration system TR2 FLASH DRUM | 2''-C41209-11420 | H | Piping | CS | INFRARED THERMOGRAPHY, PEC @ CML & proper sealing of insulation plug |
| Glycol Regeneration system TR2 Glycol Pumps | 3''-C41231-91420 | H | Piping | CS | INFRARED THERMOGRAPHY, PEC @ CML & proper sealing of insulation plug & jacketing seam |
| Glycol Regeneration system TR2 Glycol Pumps | 3''-C41234-91420 | H | Piping | CS | INFRARED THERMOGRAPHY, PEC @ CML & proper sealing of insulation plug & jacketing seam |

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| **MODULES** | **PIPING TAGS NOS.** | **INSULATION TYPE** | **EQUIPMENT TYPE** | **MATERIAL OF CONSTR.** | **Inspection Plan** |
| HP Separarator TR1 | 20''-B51014-11441 | A | Piping | CS | Infared thermography and ensure proper sealing of support & valve protrusion |
| HP Separarator TR1 | 20''-B51017-11441 | A | Piping | CS |
| HP Separarator TR 2 | 20''-B51207-11441 | A | Piping | CS |
| HP Separarator TR 2 | 20''-B51207A-11441 | A | Piping | CS |
| XHP Separarator & Heater TR 2 | 20''-B51228-13450 | A | Piping | CS |

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| **MODULES** | **PIPING TAGS NOS.** | **INSULATION TYPE** | **EQUIPMENT TYPE** | **MATERIAL OF CONSTR.** | **Inspection Plan** |
| Zarama NAG pig receiver | 20''-P10902-900# | Passive fire proofing | Piping | CS | PEC inspection |
| Gbaran E2/E4 Bulkline Pig Receiver. | 12''-P10906-2500# | Passive fire proofing | Piping | CS | PEC inspection |
| Kocr NAG Bulkline pig Receiver. | 12''-P10904-900# | Passive fire proofing | Piping | CS | PEC inspection |
| Koroama NAG Bulkline Pig Receiver. | 16''-P10910-2500# | Passive fire proofing | Piping | CS | PEC inspection |
| Gbaran XHP Pig Receiver | 10''-P12910-1500# | Passive fire proofing | Piping | CS | PEC inspection |
| Gbaran XXHP Pig Receiver. | 10''-P12911-1500# | Passive fire proofing | Piping | CS | PEC inspection |
| Kocr HP Bulkline Pig Receiver. | 18''-P12909-1500# | Passive fire proofing | Piping | CS | PEC inspection |
| Etelebou HP Bulkline Pig Receiver | 10''-P12906-1500# | Passive fire proofing | Piping | CS | PEC inspection |
| Zarama XHP Bulkline Pig Receiver. | 16''-P12912-1500# | Passive fire proofing | Piping | CS | PEC inspection |
| Zarama Test Bulkline Pig Receiver. | 6''-P12927-1500# | Passive fire proofing | Piping | CS | PEC inspection |
| Etelebou Test Bulkline Pig Receiver. | 6''-P12924-1500# | Passive fire proofing | Piping | CS | PEC inspection |
| Gbaran & Kocr Test Bulkline Pig Rec. | 6''-P12926-1500# | Passive fire proofing | Piping | CS | PEC inspection |
| Liquid Export pig launcher | 18''-P55903-600# | Passive fire proofing | Piping | CS | PEC inspection |
| BYSG Gas Export Pig launcher | 10''-F10902-300# | Passive fire proofing | Piping | PL3LC | PEC inspection |

**General Inspection Tips:**

* Develop a scheduled method of inspecting.
* Identify the physical characteristics of each insulated pipe system and equipment.
* For carbon steel, check for pitting and scaling.
* For stainless steel, check for stress corrosion cracking.
* Identify critical locations on pipe and equipment for inspection.
* Document the condition of the substrate, such as no corrosion, mild corrosion or severe corrosion.
* Document condition of the insulation, such as dry insulation or wet insulation. Schedule the replacement of wet insulation.
* Re-inspect on a yearly basis.