INCOMING INSPECTION REPORT

Customer	Nghi Son Refinery & Petrochemical, LLC.	**UNEW Work Order No.**	**825088**
Customer P.O. No.	1003946086	**Report Date**	27 April 2026
Engine Type	MS6001FA (GE Frame 6FA)	**Component**	Combustion Liner MNQC
Component Part No.	119E9620G001	**Qty. Received**	6 Units (1 Complete Set)
Material	Hastelloy-X (Body, Cowl Cap, End Ring, Floating Collar, Liner Stop) | Haynes 188 (Crossfire Collar) | Inconel X-750 (Spring Seal / Hula Skirt) | SS304 (Collar Retainer)	**As-Received Coating**	TBC Coating — Inside Body & Inside Cowl Cap (Primary Fuel Nozzle Collar and Center Bore)
Repair Classification	**HEAVY REPAIR**	**Coating Requirement**	Chrome Carbide Coating (Hula Skirt) + Class C TBC (Internal Surface)
Total Initiated Starts	476	**Total Emergency Trips**	**125**

Responsible Product Engineer: _____ Report prepared by: _____

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Report reviewed and approved by:_____

Mr. Pheerayawat Muadna

(Engineering Manager)

1. EXECUTIVE SUMMARY:

Six (6) MS6001FA combustion liners received from Nghi Son Refinery and Petrochemical, LLC. were inspected upon receipt. The inspection confirmed severe damage across all six units. Multiple heavy damage mechanisms were identified including deep cracking on the liner body and cowl cap, heavy corrosion and oxidation on internal combustion surfaces, heavy frettage at all contact areas, and serious geometric distortion of the liner body.

Cracking was found in high temperature zones and extends deep into the base material. These cracks cannot be removed by blending or minor weld repair. Full excavation and weld reconstruction is required on all affected areas. Internal corrosion has caused serious base metal loss and dangerous wall thinning across the combustion surface, putting the structural integrity of the liner at critical risk during high temperature operation.

Heavy frettage damage is confirmed at all contact points on spring seals, liner stops, crossfire collars, and floating collars across all six liners. This damage directly affects component fit and operational stability. Dimensional inspection confirmed deviation in liner body roundness and local geometric distortion that will impact combustion performance and gas flow if not corrected.

The combined severity of structural cracking, base metal loss, wall thinning, heavy frettage, and geometric distortion confirms that these components are beyond standard or medium repair. All six combustion liners are classified as **HEAVY REPAIR** by UNEW Engineering.

The repair will require full coating removal, complete crack excavation and weld rebuild, liner body correction to restore original geometry, and full heat treatment after welding to recover material properties. All fretted and worn areas will be fully rebuilt and re-machined. After structural repair is complete, internal surfaces will be recoated with MCrAlY bond coat and Thermal Barrier Coating. The hula skirt wear area will receive Chrome Carbide hard coating. No components are recommended for scrap. All six liners are within the Heavy Repair limits established by UNEW Engineering and will be restored in accordance with UNEW approved repair procedures and quality standards.

2. INTRODUCTION

Six (6) MS6001FA combustion liners were received and inspected. The inspection identified cracking on the liner body and cowl cap, corrosion and oxidation on internal surfaces, frettage at contact areas, and distortion of the liner geometry.

Some cracks extend beyond surface level and are located in high temperature zones, requiring full removal and rebuild. Corrosion on the internal combustion surface has caused loss of base material and thinning of the liner wall. Frettage on spring seals, liner stops, and collars affects fit-up and stability. Dimensional checks also show deviation in roundness and local distortion, which can impact combustion performance.

Based on these conditions, the liners require heavy repair. Local blending or minor weld repair is not sufficient, and damaged areas must be fully removed and rebuilt.

The repair will include complete coating removal, crack removal, and weld build-up to restore structure. The liner body will be corrected for distortion and returned to original geometry. Heat treatment will be applied after welding to recover material properties, and worn areas will be rebuilt and machined to proper fit.

After repair, internal surfaces will be recoated with bond coat and thermal barrier coating, and wear areas such as the hula skirt will receive hard coating.

The repair will return the liners to a stable operating condition with correct geometry, restored material properties, and protection for high temperature service.

Order Information		
EE Work Order no.		825088
Date of report		27 April 2026
Customer W.O. no.		1003946086
Component Details		
Engine type		MS6001FA
Component type		Combustion liner MNQC
Component part number		119E9620G001
Qty. received		6
Material type (s)	Body	Hastelloy-X
	Cowl cap	Hastelloy-X
	End ring	Hastelloy-X
	Floating collar	Hastelloy-X
	Collar retainer	SS304
	Liner stop	Hastelloy-X
	Crossfire collar	Haynes 188
	Spring seal (Hula skirt)	Inconel X-750
As received coating type (s)	Inside body	TBC coating
	Inside cowl cap	TBC coating (primary fuel nozzle collar and center bore)
Customer supplied component history		
Total Initiated Starts		476
Manually Initiated Starts		468
Fired Starts		180
Total Emergency Trips		125
Breaker Tripped At Load Count		127

3. INSPECTION SUMMARY

The following operational history increases the risk profile and supports the Heavy Repair classification:

- Total Initiated Starts: 476, Manually Initiated Starts: 468, Fired Starts: 180
- Total Emergency Trips: 125 a critically high count confirming repeated severe thermal shock events that accelerate deep cracking, hot corrosion, and material degradation across the liner body and cowl cap.
- Breaker Trips at Load: 127 consistent with heavy cyclic thermal loading causing fatigue crack propagation and frettage damage at all contact interfaces.

The following damage categories were identified across all 6 combustion liners and collectively confirm the Heavy Repair classification:

Damage Category	Finding (As Inspected)	Disposition
Cracking at Liner Body	Deep cracks 2 to 4 mm extending beyond surface level in high temperature zones across all 6 liners. Full excavation and weld rebuild required.	**Weld and Blend**
Cracking at Cowl Cap	2 mm crack confirmed at cowl cap on Item 5. Severely degraded cowl cap condition observed across the set requiring weld repair.	**Weld and Blend**
Heavy Corrosion and Oxidation on Internal Body Surface	Heavy corrosion confirmed on internal combustion surfaces across all 6 liners. Serious base metal loss and dangerous wall thinning observed. Full material removal and restoration required.	**Blend and Weld Build-up**
Heavy Frettage at Spring Seals	Heavy frettage confirmed on all spring seals across all 6 liners. Directly affects component fit and liner stability during operation.	**Blend Repair**
Heavy Frettage at Liner Stops	Heavy frettage confirmed on liner stops across all 6 liners. Affects structural fit and liner positioning during high temperature operation.	**Blend Repair**
Frettage at Crossfire Collars and Floating Collars	Frettage wear confirmed on crossfire collars (2 per liner) and floating collars (6	**Blend Repair**

	per liner) across all 6 liners. Wear affects sealing and fit between components.	
End Ring Roundness Out of Limit	End ring roundness measurements recorded as REJECT on all 6 liners. Dimensional deviation will affect assembly fit and combustion stability if not corrected.	**Dimensional Restoration**
Spring Seal Diameter Out of Limit	Spring seal diameter measurements recorded as REJECT on all 6 liners. Out-of-limit diameter will affect sealing effectiveness and liner stability during operation.	**Dimensional Restoration**
Liner Body Geometric Distortion	Local distortion of the liner body confirmed across the set. Distortion will impact combustion performance and gas flow path if not corrected to original geometry.	**Cold Press and Reshape**
Full TBC Coating Degradation	Internal TBC coating on liner body and cowl cap is severely degraded. Full coating removal and reapplication of MCrAlY bond coat and TBC is required across all 6 liners.	**Full Strip and Recoat**

3.1 DIMENSIONAL INSPECTION SUMMARY

Key dimensional findings from the incoming inspection are summarized below:

Inspection Parameter	Result	Status
Liner Body Roundness (F-Roundness)	Range 5.85 to 6.47 mm across all 6 liners. Deviation confirms liner body distortion requiring cold press correction.	SLIGHT OUT OF LIMIT
End Ring Roundness	All 6 liners recorded as REJECT. Out-of-limit roundness requires dimensional restoration before assembly.	**REJECT — 6/6**
Spring Seal Diameter	All 6 liners recorded as REJECT. Out-of-limit diameter directly affects sealing effectiveness and liner stability.	**REJECT — 6/6**

Crossfire Collar ID	All crossfire collar internal diameters within acceptable limits across all 6 liners.	SLIGHT OUT OF LIMIT
Wall Thickness	Wall thickness measurements within acceptable limits. However, internal corrosion has caused localized thinning of the combustion surface requiring material restoration.	SLIGHT OUT OF LIMIT
Liner Body Length (Y1, Y2, Y3)	Y1 range 47.67 to 48.11 mm. Y2 range 47.65 to 47.99 mm. Y3 range 39.15 to 39.75 mm. Results recorded for baseline reference.	SLIGHT OUT OF LIMIT
Outer Diameter (E)	Range 392.50 to 393.60 mm across all 6 liners. Recorded for baseline reference and post-repair dimensional verification.	SLIGHT OUT OF LIMIT

3.2 HEAVY CRACKING AT LINER BODY AND COWL CAP (100% OF LINERS AFFECTED)

Visual inspection and fluorescent penetrant inspection (FPI) confirmed that all 6 combustion liners exhibit cracking on the liner body and cowl cap. This is the primary driver for Heavy Repair classification:

- Liner body cracking: Deep cracks of 2 to 4 mm confirmed across all 6 liners. Cracks are located in high temperature zones and extend beyond surface level. Simple blending or minor weld repair is not sufficient. Full excavation of all cracked material and complete weld reconstruction is required.
- Cowl cap cracking: A 2 mm crack was confirmed at the cowl cap on Item 5. Severely degraded cowl cap condition was observed across the full set as confirmed in photographs (Figs. 7 and 8). Weld repair and rebuild is required.
- All cracking confirmed in this set extends beyond the level that can be addressed by standard or medium repair methods. Full Heavy Repair intervention with GTAW weld reconstruction is mandatory across all 6 liners.

3.3 HEAVY CORROSION AND OXIDATION ON INTERNAL COMBUSTION SURFACE

Photographs (Figs. 11 to 16) confirm heavy corrosion and oxidation across all internal combustion surfaces:

- Heavy corrosion on the internal body surface has caused serious base metal loss and dangerous thinning of the liner wall across all 6 liners. This condition puts the structural integrity of the liner at critical risk during high temperature operation.
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- Heavy corrosion damage is confirmed across the full internal combustion surface area and cannot be removed by blending alone. Weld build-up and material restoration is required to recover original wall thickness and structural strength.
- The severity of corrosive attack is consistent with extended high temperature operation without repair intervention, combined with the high emergency trip count of 125 trips which accelerates corrosion damage through repeated thermal cycling.

3.4 HEAVY FRETTAGE AT ALL CONTACT AREAS (100% OF LINERS AFFECTED)

Heavy frettage damage was confirmed at all contact interfaces across all 6 liners:

- Spring seals: Heavy frettage confirmed on all spring seals across all 6 liners (Figs. 9 and 10). This directly affects the fit and stability of the liner during operation and must be fully repaired.
- Liner stops: Heavy frettage confirmed on liner stops across all 6 liners (Figs. 20 and 21). Wear damage affects liner positioning and structural fit at this critical interface.
- Crossfire collars: Heavy frettage confirmed on crossfire collars (2 per liner) across the complete set (Fig. 19). Frettage wear at these locations affects the crossfire tube sealing and inter-liner combustion stability.
- Floating collars: Frettage wear confirmed on floating collars (6 per liner) across all 6 liners (Figs. 23 and 24). Wear at these locations affects component fit and sealing effectiveness.
- All fretted areas will be fully rebuilt by weld build-up and re-machined to restore original fit dimensions in accordance with UNEW approved repair procedures.

3.5 LINER BODY GEOMETRIC DISTORTION

Dimensional inspection confirmed geometric deviation of the liner body across the complete set. Local distortion of the liner body will directly impact combustion performance, gas flow path stability, and sealing effectiveness if not corrected. Cold press operations will be performed on all 6 liners to restore the liner body to original geometry before any weld repair or coating work proceeds.

3.6 END RING ROUNDNESS AND SPRING SEAL DIAMETER, ALL 6 LINERS REJECTED

Post-strip dimensional inspection confirmed that both end ring roundness and spring seal diameter are out of acceptable limits on all 6 liners:

- End ring roundness: All 6 liners recorded as REJECT. Out-of-limit roundness requires dimensional restoration to ensure correct assembly fit and combustion stability.
- Spring seal diameter: All 6 liners recorded as REJECT. Out-of-limit spring seal diameter directly affects sealing effectiveness and liner stability during high temperature operation.
- Corrective action: Dimensional restoration will be performed on all end rings and spring seals across the complete set in accordance with UNEW approved procedures. Final dimensional verification will be performed before assembly and coating.

3.7 FULL TBC COATING DEGRADATION

The as-received TBC coating on the internal body surface and cowl cap has deteriorated to a level requiring complete removal and full reapplication. Full abrasive blast, MCrAlY bond coat application, and Class C TBC reapplication are required across all 6 liners. The hula skirt wear area will receive Chrome Carbide hard coating by APS process. All coating operations will be performed in accordance with UNEW approved coating procedures.

Repair requirements		
DESCRIPTION	QTY	UNIT
Incoming inspections	1	set
Heavy Repair	1	set
Chrome Carbide Coating to Hula skirt and Class C TBC internal surface	1	set

4. SPARE PART (Repair / Replace):

Item	Part description	Received / Required	Condition	Quantity	Remark
1	End ring	6/6	Replace	6	In scope
2	Spring seal (or Hula skirt)	6/6	Replace	6	In scope
3	Crossfire collar	12/12	Replace	12	Additional
4	Liner stop	18/18	Replace	18	Additional
5	Floating Collar	36/36	Replace	36	Additional
6	Collar retainer	36/36	Replace	36	Additional
10	Cowl cap rivet	72/72	Replace	72	Additional

5. ENGINEERING RECOMMENDATION

Following receipt, cleaning, coating removal, incoming solution heat treatment, visual inspection, fluorescent penetrant inspection (FPI), wall thickness measurement, dimensional inspection, and metallurgical evaluation, UNEW Engineering has assessed all 6 MS6001FA combustion liners (UNEW Work Order 825088) received from Nghi Son Refinery and Petrochemical, LLC.

The severity and extent of damage found across the complete set — including deep structural cracking on the liner body and cowl cap, heavy internal corrosion with base metal loss, heavy frettage at all contact areas, liner body geometric distortion, and full TBC coating degradation — confirms that this set requires HEAVY REPAIR. No liner in the set is eligible for a lower repair classification.

The following operational factors were noted as contributors to the damage severity:

- 476 Total Initiated Starts with 125 Emergency Trips — critically high cyclic thermal load causing deep fatigue cracking at the liner body and cowl cap, and accelerating hot corrosion on the internal combustion surface.
- 127 Breaker Trips at Load — consistent with rapid and repeated thermal shock events that accelerate frettage damage at all contact interfaces and drive progressive crack propagation.
- No service history, fuel type, or maintenance interval data was provided by the customer. A conservative Heavy Repair approach has been applied across the complete set.

5.1 DEFECT FINDINGS AND RECOMMENDED REPAIR ACTIONS

The table below defines the required repair action for each defect category identified during incoming inspection. All repair methods shall be performed in accordance with UNEW approved repair procedures.

No.	Defect / Condition	Location / Affected Items	Repair Method	Action
1	**Heavy cracking at liner body**	Deep cracks 2 to 4 mm in high temperature zones across all 6 liners. Full excavation and weld rebuild required.	**GTAW Weld and Blend**	**REQUIRED**
2	**Cracking at cowl cap**	2 mm crack at cowl cap Item 5. Severely degraded cowl cap condition across full set.	**GTAW Weld and Blend**	**REQUIRED**
3	**Heavy corrosion and oxidation on internal combustion surface**	Serious base metal loss and wall thinning confirmed on internal combustion surfaces across all 6 liners.	**Blend and Weld Build-up**	**REQUIRED**
4	**Heavy frettage at spring seals**	Heavy frettage confirmed on all spring seals across all 6 liners. Affects liner fit and stability.	**Blend Repair**	**REQUIRED**

5	**Heavy frettage at liner stops**	Heavy frettage confirmed on liner stops across all 6 liners. Affects liner positioning and structural fit.	**Blend Repair**	**REQUIRED**
6	**Frettage at crossfire collars**	Frettage wear on crossfire collars (2 per liner) across all 6 liners. Affects crossfire tube sealing.	**Blend Repair**	**REQUIRED**
7	**Frettage at floating collars**	Frettage wear on floating collars (6 per liner) across all 6 liners. Affects component fit and sealing.	**Blend Repair**	**REQUIRED**
8	**End ring roundness out of limit**	All 6 liners REJECT. Deviation affects assembly fit and combustion stability.	**Dimensional Restoration**	**REQUIRED**
9	**Spring seal diameter out of limit**	All 6 liners REJECT. Out-of-limit diameter affects sealing effectiveness and liner stability.	**Dimensional Restoration**	**REQUIRED**
10	**Liner body geometric distortion**	Local distortion confirmed across the full set. Affects combustion performance and gas flow path.	**Cold Press and Reshape**	**REQUIRED**
11	**Full TBC coating degradation**	Internal TBC on liner body and cowl cap severely degraded. Full removal and reapplication required on all 6 liners.	**Full Strip and Recoat**	**REQUIRED**

NOTE: *All weld repairs (GTAW) will be performed using approved filler materials compatible with Hastelloy-X base alloy. Pre-weld and post-weld fluorescent penetrant inspection (FPI) is mandatory for all weld repaired areas. Heat treatment will be applied after all welding operations are complete.*

5.2 RECOMMENDED REPAIR SEQUENCE

All components shall be repaired in the following sequence to ensure structural integrity and coating adhesion:

Step	Process	Applies To
1	Receipt inspection, serial number recording and verification on body and cap assembly	All 6 Liners
2	Metallurgical evaluation of base material and coating type, report on condition	All 6 Liners
3	Dimensional inspection and pre-strip wall thickness inspection	All 6 Liners
4	Abrasive blast to remove TBC and MCrAlY coating and clean all surfaces. Assess bond coat condition.	All 6 Liners
5	Visual inspection and fluorescent penetrant inspection (FPI). Record all defects.	All 6 Liners

6	Post-strip wall thickness inspection. Report all non-conformities.	All 6 Liners
7	Compile incoming inspection report and forward to customer for discussion and approval.	All 6 Liners
8	Blend to remove oxidation on combustion liner body	All 6 Liners
9	Scallop to remove all defective material from liner body in preparation for weld repair	All 6 Liners
10	Scallop to remove defective material from crossfire collar in preparation for weld repair	All 6 Liners
11	Scallop to remove defective material from ignitor assembly in preparation for weld repair	All 6 Liners
12	Scallop to remove defective material from liner stops in preparation for weld repair	All 6 Liners
13	GTAW weld repair to liner body — all cracked and missing material areas	All 6 Liners
14	GTAW weld repair to crossfire collars	All 6 Liners
15	GTAW weld repair to liner stops	All 6 Liners
16	GTAW weld repair to ignitor assembly	All 6 Liners
17	Blend all weld repaired areas to restore component profile	All 6 Liners
18	Cold press to reinstate combustion liner body to original geometry	All 6 Liners
19	Abrasive blast all surfaces	All 6 Liners
20	Fluorescent penetrant inspection (FPI) — post-repair verification	All 6 Liners
21	Visual inspection	All 6 Liners
22	Dimensional inspection and ultrasonic wall thickness inspection. Report all non-conformities.	All 6 Liners
23	Heat treatment after welding to restore material properties and relieve residual stresses	All 6 Liners
24	Pre-coat fixture check	All 6 Liners
25	Apply Chrome Carbide hard coating by APS process to hula skirt	All 6 Liners
26	Apply MCrAlY bond coat by APS process to internal gas path surface	All 6 Liners
27	Apply Class C Thermal Barrier Coating (TBC) by APS process to liner body	All 6 Liners
28	Demask, dress and perform visual inspection after coating	All 6 Liners
29	Final dimensional inspection and final visual inspection	All 6 Liners

30	Compile Final Report, pack and ship with all required documentation per Purchase Order	All 6 Liners

5.3 COATING RECOMMENDATION

The following coating scope applies to the complete set of 6 combustion liners:

Coating Process	Surface / Area	Applies To
Abrasive blast to remove existing TBC and MCrAlY coating	All internal gas path surfaces	All 6 Liners
Abrasive blast internal surface. Blow out with clean dry compressed air to remove residual media	Internal gas path surface	All 6 Liners
Apply Chrome Carbide hard coating by APS process	Hula skirt wear area	All 6 Liners
Apply MCrAlY bond coat by APS process	Internal gas path surface	All 6 Liners
Apply Class C Thermal Barrier Coating (TBC) by APS process	Liner body internal surface	All 6 Liners
Demask, dress and perform visual inspection	All coated surfaces	All 6 Liners
Final visual inspection and dimensional inspection	All surfaces	All 6 Liners

5.4 ENGINEERING RECOMMENDATION CONCLUSION

CLASSIFICATION: HEAVY REPAIR, All 6 Combustion Liners

UNEW Engineering confirms that the complete set of 6 MS6001FA combustion liners (UNEW Work Order 825088) is classified as HEAVY REPAIR based on the findings of the incoming inspection. The damage identified — deep structural cracking, heavy internal corrosion with base metal loss, heavy frettage at all contact areas, geometric distortion, and full TBC coating degradation — is consistent with extended high temperature operation under severe cyclic thermal loading conditions.

All 6 liners are within the repairable limits established by UNEW Engineering and will be restored to a serviceable condition in accordance with the Heavy Repair work scope defined in this report. All repair methods, heat treatment programs, weld procedures, and coating processes will be performed in accordance with UNEW approved process specifications and quality procedures.

6.0 MATERIAL EVALUATION AND RECOMMENDATION

Report No.	L11384	**Job Order No.**	825088
Serial No. (or ID)	Item 2	**Cutting Location**	Body
Received Status	As-Received	**Hardness Test**	Not recorded
Grain Size	Not recorded	**Coating Type**	TBC Coating
Nearest Alloy	Hastelloy-X		

Element	Co	Cr	Ni	Mo	Fe	Ti	W	Al
Nominal (%)	—	22.0	49.0	9.0	15.8	—	—	—
Result (%)	—	20.0	48.4	9.2	19.6	—	—	—

Fig.1 Heavy TBC coating breakdown with severe damage at the coating and substrate interface (Etched) Fig.2 Heavy internal corrosion damage confirmed at high magnification (Etched)

Specimen L11384 was prepared and examined to evaluate the base metal condition at the liner body — one of the most severely damaged areas in this set. Examination confirmed the material as Hastelloy-X. The internal TBC coating showed severe degradation with heavy breakdown at the coating and substrate interface, refer to Fig.1. Heavy corrosion and oxidation were confirmed on the internal combustion surface, causing serious base metal loss and dangerous wall thinning of the liner body. Although the base metal microstructure showed a stable gamma matrix with normal carbide distribution, the severity of the surface damage and full coating breakdown confirms that the liner is well beyond standard or medium repair and requires full Heavy Repair intervention across the complete set. The base metal composition result is consistent with the Hastelloy-X nominal specification, confirming the alloy identity and suitability for weld repair, refer to Fig.2.

Recommendation

Based on the examination above, the severe TBC coating breakdown and heavy internal corrosion confirmed at the liner body require full coating removal and complete excavation of all corroded and degraded material, followed by weld build-up to restore base metal integrity and wall thickness. Although the Hastelloy-X base metal microstructure is confirmed acceptable for repair, the surface damage is so severe that mandatory full material restoration is required before any coating can be applied.

The material is now approved to proceed with Heavy Repair. All welding operations must use approved filler materials compatible with Hastelloy-X alloy and must be performed in accordance with UNEW approved weld repair procedures. Controlled heat treatment is mandatory after all welding operations are complete to restore material properties and relieve residual stresses. After structural repair is confirmed, a new coating system comprising MCrAlY bond coat and Class C TBC will be applied to all internal gas path surfaces. Chrome Carbide hard coating will be applied to the hula skirt wear area in accordance with UNEW approved coating procedures.

7. PACKING LIST FROM CUSTOMER:

Description	MAXIMO	P/N	S/N	UOM	Box	DIM (CM)	Gross Weight	Net Weight
CAP AND LINER ASSY	2060129788	119E9620G001	11151561 11160952 11151560 11160951 11151558 11151559	PC	1/8	H135 X W115 X L151	310	186

7. COMPONENT SERIAL NUMBER CORRELATION:

CORRELATION SHEET			
Item	Part number	Serial number	Material
1	119E9620G001	11151561	Hastelloy-X
2	119E9620G001	11160952	Hastelloy-X
3	119E9620G001	11151560	Hastelloy-X
4	119E9620G001	11160951	Hastelloy-X
5	119E9620G001	11151558	Hastelloy-X
6	119E9620G001	11151559	Hastelloy-X

8. SCOPE OF WORK:

Standard Work scope	Inspect	Heavy	Coating
Inspection			
Perform receipt inspection and record serial numbers. Ensure serial numbers etch on body and cap assembly.	X		
Perform metallurgical evaluation of base material and coating type, report on condition	X		
Perform dimensional inspection	X		
Perform pre strip thickness inspection	X		
Abrasive blast to remove Thermal Barrier Coating and MCrAlY coating and to clean all surfaces. Assess the bond coat	X		
Perform visual inspection, record all defects.	X		
Perform penetrant inspection and record all defects.	X		
Perform post strip thickness inspection.	X		
Compile incoming inspection and forward copy to customer for discussion.	X		
Repair			
Blend to remove oxidation product on combustion liner body		X	
Scallop to remove defective material in preparation for weld repair - liner body		X	
Scallop to remove defective material in preparation for weld repair - X-fire collar		X	
Scallop to remove defective material in preparation for weld repair - ignitor assembly		X	
Scallop to remove defective material in preparation for weld repair - liner stops		X	
Perform weld repairs to liner body		X	
Perform weld repairs to X-fire collars		X	
Perform weld repairs to liner stops		X	
Perform weld repairs to ignitor assembly		X	
Blend all weld repaired areas to restore component profile		X	
Cold press to reinstate Combustion liner body		X	
Abrasive blast all surfaces		X	
Perform penetrant inspection		X	
Perform visual inspection		X	
Perform dimensional inspection		X	
Perform ultrasonic thickness inspection and report all non-conformities.		X	

Perform Pre Coat fixture check		X	
Coating			
Abrasive blast gas path surfaces to receive coating.			X
Apply Hard face coating by APS process to hula skirt			X
Demask, dress and perform visual inspection			X
Abrasive blast internal surface. Blow out with clean dry compressed air to remove any residual media			X
Apply MCrAlY bond coat by APS process to internal gas path surface			X
Apply Thermal Barrier Coating (TBC) by APS to liner body			X
Demask, dress and perform visual inspection			X
Perform final dimensional inspection			X
Perform final visual inspection			X
Compile Final Report, pack and ship components with all required documentation as listed in Purchase Order			X

Required:

- Chrome Carbide Coating to Hula skirt and Class C TBC internal surface (standard work scope).

9.0 MATERIAL EVALUATION AND RECOMMENDATION

Report No.	L11384	Job order no.	825088
Serial no.(or ID)	Item# 2	Cutting location	Body
Received status	☑ As-Received ☐ Pre-Weld HT ☐ Post-Weld HT ☐ Other		

Analysis Result

Main composition,%										Hardness Test	-
Element	Co	Cr	Ni	Ti	W	Ta	Mo	Fe	Al	Grain size	-
Nominal	-	22.0	49.0	-	-	-	9.0	15.8	-	Coating Type	TBC coating
Result	-	20.0	48.4	-	-	-	9.2	19.6	-	Nearest Alloy	Hastelloy-X

Microstructure

Fig.1 Showing the hot gas path coating and substrate condition.(Etched)

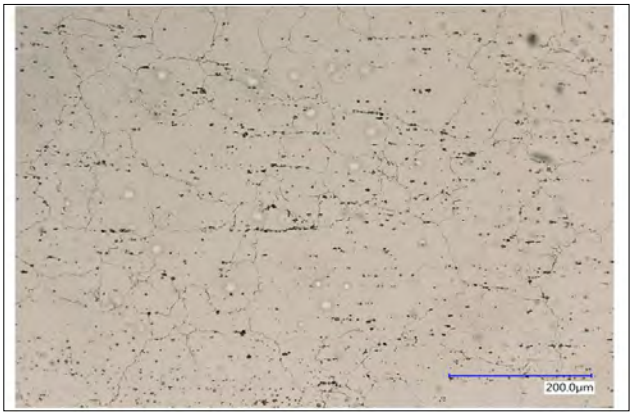


Fig.2 Showing the typical microstructure at higher magnification.(Etched)

A metallurgical sample was taken from the liner body to assess the condition of the base material. The analysis confirms the material as Hastelloy-X with a stable gamma matrix and normal carbide distribution. No abnormal metallurgical degradation was observed.

The internal coating system is degraded, and inspection shows oxidation and localized material loss on the combustion surface. These conditions require full removal of coating and affected material during repair.

Based on the evaluation, the base material remains suitable for heavy repair. All degraded areas, including cracks, oxidation, and weakened sections, will be completely removed, followed by weld reconstruction using compatible high-temperature filler material.

All repaired components will undergo controlled heat treatment to restore material properties and relieve residual stresses, consistent with the defined repair scope.

After repair, a new coating system, including MCrAlY bond coat and thermal barrier coating, will be applied to restore protection for high temperature operation.

10.0 PHOTOGRAPHS:

Fig.1 As-received condition.

Fig.2 As-received condition.

Fig.3 As-received condition.

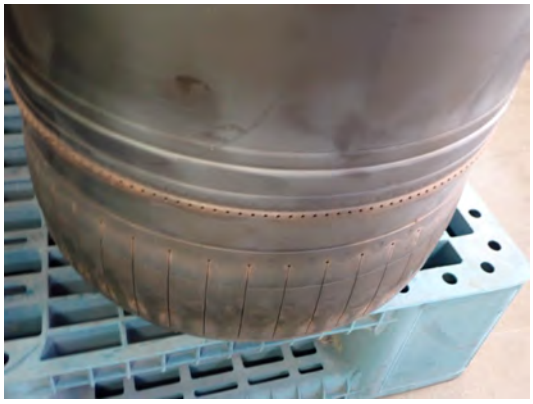


Fig.4 As-received condition.

Fig.5 Typical condition of body.

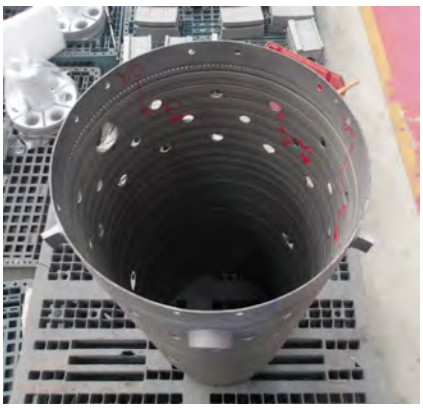


Fig.6 Typical condition of body

Fig.7 Severely degraded condition of cowl cap

Fig.8 Severely degraded condition of cowl cap

Fig.9 Heavy frettage on spring seals.

Fig.10 Heavy frettage on spring seals.

Fig.11 Heavy corrosion on internal body.

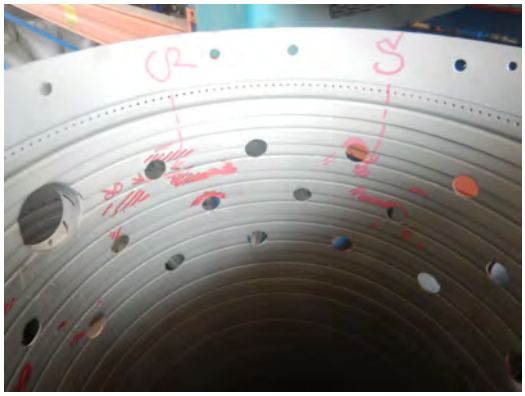


Fig.12 Heavy corrosion on internal body.

Fig.13 Several heavy corrosion on internal body.

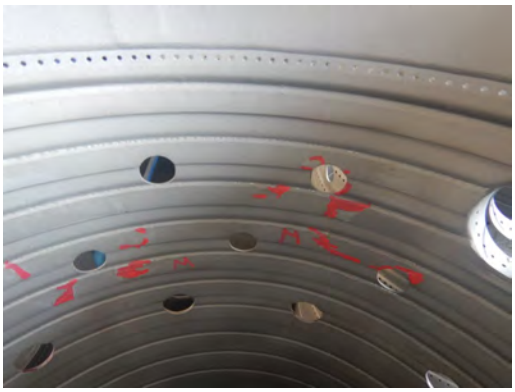


Fig.14 Several heavy corrosion on internal body.

Fig.15 Heavy corrosion across body.

Fig.16 Heavy corrosion across body.

Fig.17 Crack across entire body.

Fig.18 Crack across entire body.

Fig.19 Heavyfrettage on crossfire collar.

Fig.20 Heavy frettage on liner stop.

Fig.21 Heavy frettage on liner stop.

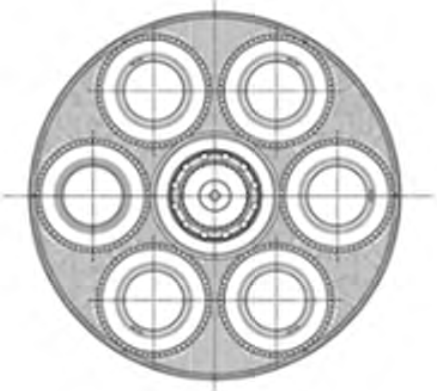
Fig.22 Heavy crack on cowl cap.

Fig.23 Frettage on floating collar.

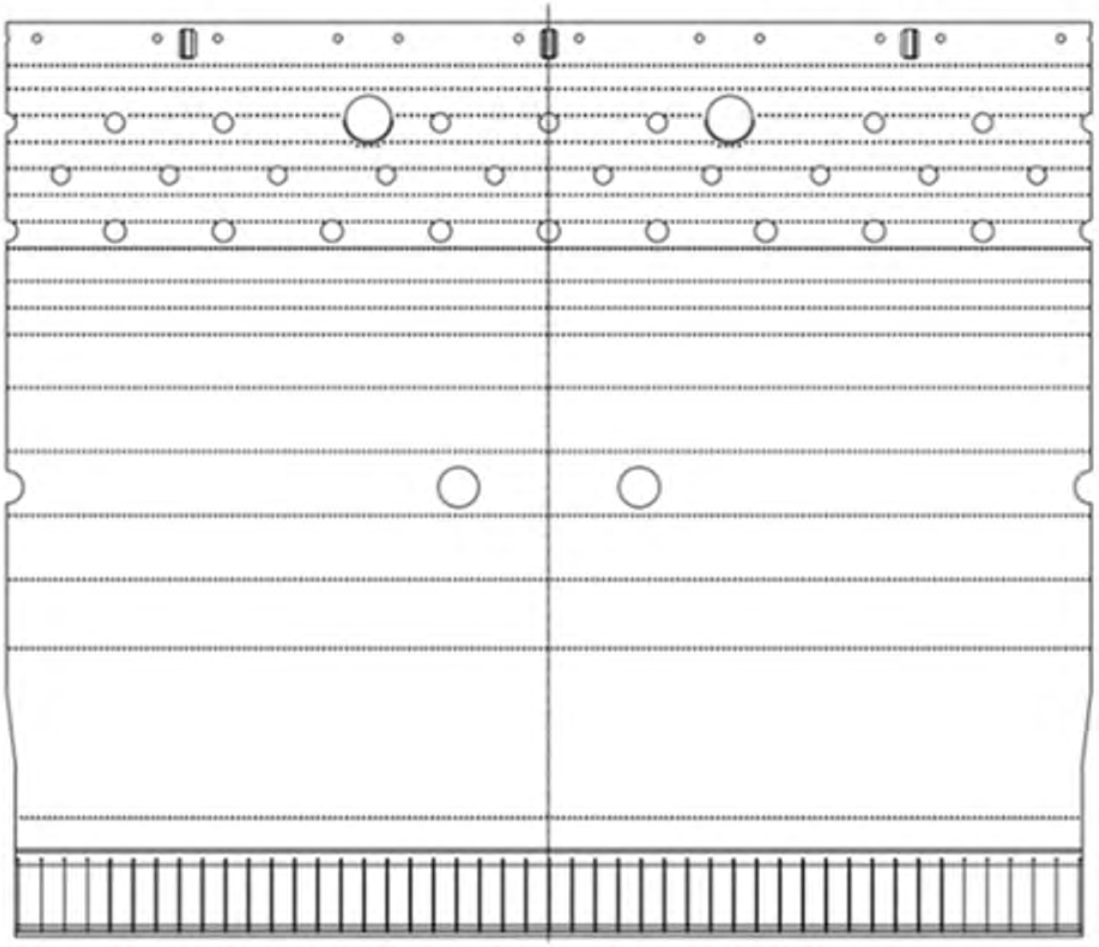
Fig.24 Frettage on floating collar.

10. DEFECT LEGEND TABLE:

TOP



BOTTOM



EthosEnergy

INCOMING INSPECTION REPORT

Item No.	INSPECTION FINDINGS																		
	Body				Spring seal				End ring				Cowl cap				Liner Stop		
	Cracking	Corrosion	Missing material	Deformation	Wear	Deformation	Missing material	Cracking	Wear	Deformation	Missing material	Cracking	Wear	Deformation	Cracking	Foreign Object	Wear	Cracking	Corrosion
1	WB	B/WB			B												B		
2	WB	B/WB			B														
3	WB	B/WB			B												B		
4	WB	B/WB			B														
5	WB	B/WB			B												B		
6	WB	B/WB			B												B		

Item No.	INSPECTION FINDINGS														DIMENSIONAL DATA			
	Collar retainer			Crossfire collar (2 per liner)						Floating collar (6 per liner)								
	Wear	Cracking	Corrosion	Wear		Deformation		Cracking		Wear		Missing material		Cracking		End ring roundness	Spring seal diameter	Crossfire ID (2)	Wall thickness
				Qty	Code	Qty	Code	Qty	Code	Qty	Code	Qty	Code	Qty	Code				
1	B									6	B					REJ	REJ	ACC	ACC
2	B									6	B					REJ	REJ	ACC	ACC
3	B									6	B					REJ	REJ	ACC	ACC
4	B									6	B					REJ	REJ	ACC	ACC
5	B									6	B			1	WB	REJ	REJ	ACC	ACC
6	B									6	B					REJ	REJ	ACC	ACC

B = Blend repair to be performed in accordance with the location blend limits.

JK = jacking and contouring to be performed based on the deformation and distortion detected.

WB = Weld and Blend to be performed based on the area limits and defects detected.

WM = Weld and Machining to be performed to build material dimensions and restore original dimensions and contours.

WE = Welding and Electric discharge machining (EDM) to be performed to build material dimensions and restore original dimensions.

TPR = Transient Phase Restoration to be performed based on the defects detected.

R = Replace with new.

ACC = Acceptable as is.

REJ= Dimension unacceptable and will require repair or cause of scrap.

S = Non-repairable / Scrap

L = Light repair category

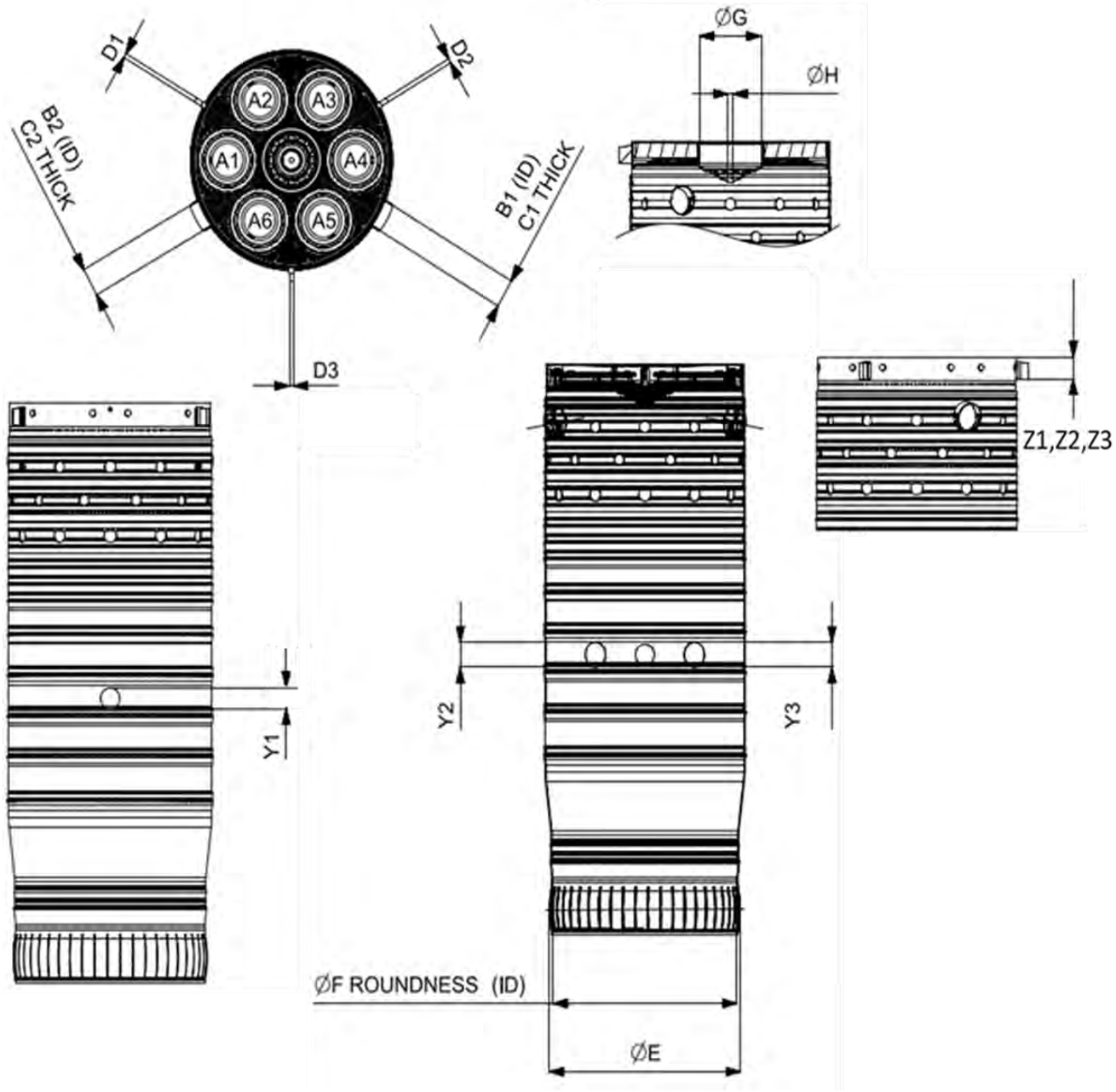
M = Medium repair category

H = Heavy repair category

EX = Salvation repair category

Work Order: 825088	**MS6001FA COMBUSTION LINER MNQC**

11. DIMENSION INSPECTION:



Work Order: 825088	**MS6001FA COMBUSTION LINER MNQC**

INCOMING INSPECTION REPORT

Dimension Inspection										
ITEM	POSITION									
	A1	A2	A3	A4	A5	A6	G	H	B1	B2
1	64.66	64.68	64.59	64.63	64.47	64.59	127.81	9.85	52.58	52.73
2	64.50	64.57	64.58	64.51	64.51	64.66	127.71	9.85	52.70	52.65
3	64.51	64.72	64.50	64.58	64.61	64.58	127.75	9.99	52.44	52.35
4	64.68	64.75	64.60	64.61	64.55	64.59	128.01	9.89	52.48	53.20
5	64.50	64.63	64.60	64.60	64.55	64.52	127.72	9.98	52.49	52.63
6	64.63	64.57	64.63	64.62	64.50	64.48	128.06	9.86	52.68	52.46

ITEM	POSITION									
	C1	C2	D1	D2	D3	Z1	Z2	Z3	F	F-roundness
1	1.61	1.63	8.55	8.61	8.57	41.00	40.73	40.73	383.72	6.24
2	1.57	1.65	8.51	8.59	8.60	41.15	40.72	40.72	381.88	6.47
3	1.55	1.63	8.53	8.58	8.57	41.17	41.04	41.04	382.01	6.17
4	1.60	1.62	8.61	8.61	8.58	41.23	41.24	41.24	382.69	5.98
5	1.60	1.63	8.56	8.56	8.57	41.14	41.46	41.46	381.16	6.21
6	1.51	1.54	8.53	8.55	8.53	41.26	41.17	41.17	381.59	5.85

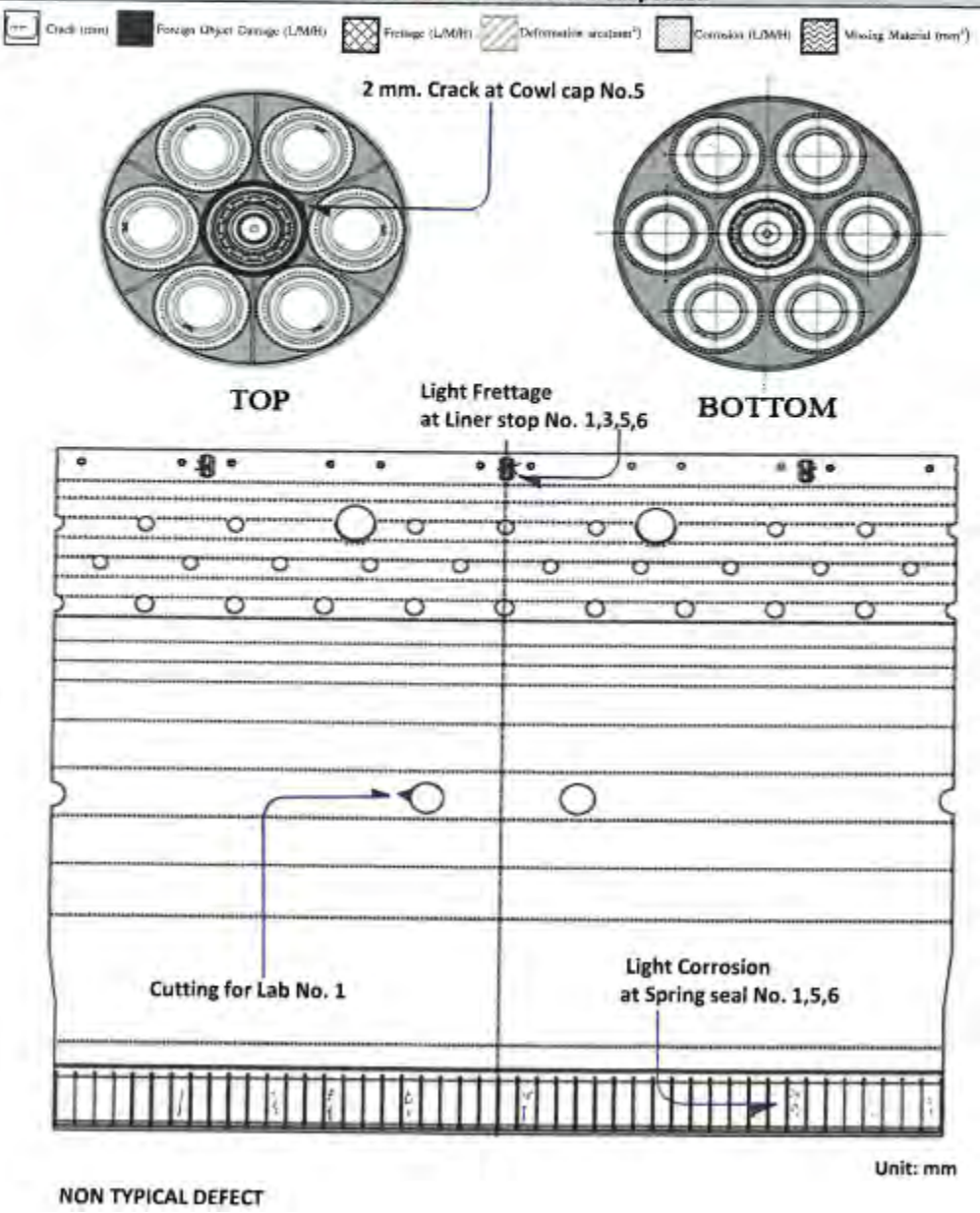
ITEM	POSITION						
	E	Y1	Y2	Y3	Z1	Z2	Z3
1	393.20	47.79	47.82	39.61	41.28	41.47	40.85
2	393.30	48.11	47.90	39.75	41.36	41.25	40.94
3	393.60	47.67	47.65	39.50	41.11	41.21	41.05
4	393.10	47.75	47.99	39.22	41.58	41.33	41.05
5	392.50	47.71	47.68	39.21	41.53	41.20	41.40
6	392.90	47.81	47.80	39.15	41.52	41.49	41.26

Unit: mm

12. DEFECT MAP:

INSPECTION AND PROCESS RECORD SHEET	MS6001FA COMBUSTION LINER MNQC	IPRS NO.	3841-50
	PART NUMBER : GECL01M6FA	REV.	00
CUSTOMER :	Nghi Son Refinery	CUSTOMER PO :	
JOB NUMBER :	825088	OP.	0090
INSPECTED BY :	Methee	DATE :	28/03/2026

Mapping of FPI and Visual Inspection

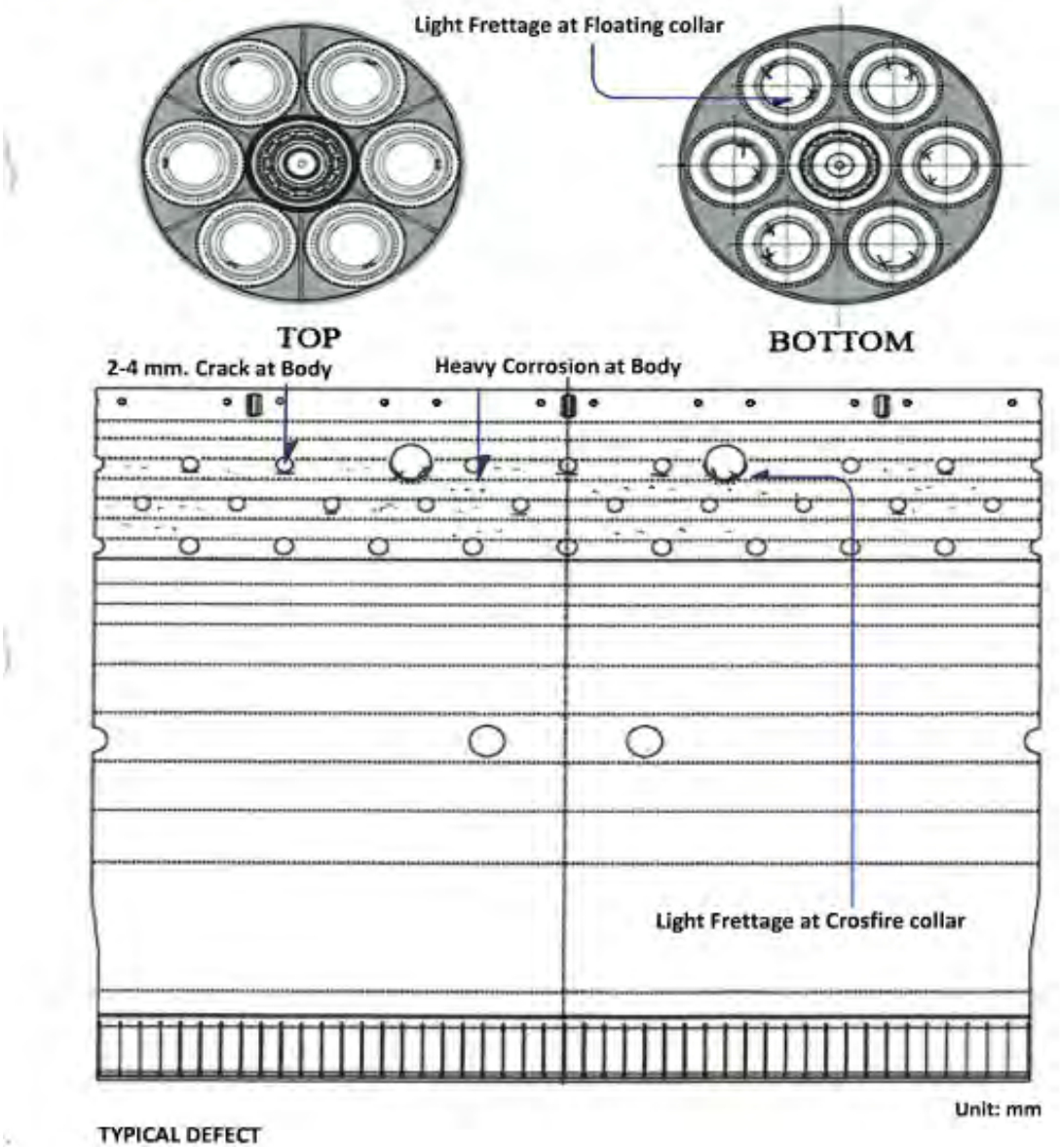


NON TYPICAL DEFECT

INSPECTION AND PROCESS RECORD SHEET	MS6001FA COMBUSTION LINER MNQC	IPRS NO.	3841-50
	PART NUMBER : GECL01M6FA	REV.	00
CUSTOMER :	Nghi Son Refinery	CUSTOMER PO :	
JOB NUMBER :	825088	OP.	0090
INSPECTED BY :	Methee	DATE :	28/03/2026

Mapping of FPI and Visual Inspection

Crack (mm) | Foreign Object Damage (LM/H) | Frettage (LM/H) | Deformation area(cm²) | Corrosion (LM/H) | Missing Material (cm²)



TYPICAL DEFECT

13. REPAIR CLASSIFICATION COMPARISON: STANDARD VS. HEAVY

Technical Category	Standard/Medium Repair	Heavy Repair (WO 825088)	Impact (Time & Cost)
Base Material Condition	Surface oxidation; minor pitting.	Deep cracks (2-4mm) & wall thinning from corrosion.	2.5x Cost / 2x Time
Structural Integrity	Geometry remains in limits.	REJECTED end ring roundness & distortion.	2.0x Cost / 2.5x Time
Metallurgy	Basic stress relief.	Full Vacuum Solution Anneal (Heat Treat).	3.0x Cost / 3.0x Time
Repair Method	Blend & minor welding.	Full excavation, weld rebuild, & re-machining.	2.0x Cost / 2.0x Time
Quality & Coating	Standard inspection & TBC.	Enhanced NDT (FPI/UT) & Class C TBC.	1.5x Cost / 1.5x Time

13.1. JUSTIFICATION FOR INCREASED RESOURCE ALLOCATION

• Time Impact: Standard repairs focus on surface cleanup. Heavy Repair requires deep scallop excavation of 2-4mm cracks across all units, multi-pass GTAW rebuilds, and a mandatory structural 'cold press' to fix rejected geometry. This more than doubles the man-hour requirement.

• Material & Special Processing Cost: Solution annealing in a vacuum furnace is a high-energy, high-cost process necessary to restore the Hastelloy-X properties lost during the 125 thermal shock (trip) events. This is not included in standard repair budgets.

13.2. ENGINEERING VERDICT

The Heavy Repair scope is mandatory to ensure the operational safety of the Nghi Son power generator. Lowering the scope would leave structural defects in place, risking catastrophic in-service failure.

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Subject: Refurbishment Incoming Inspection Reports and Capital Parts Condition

Dear NSRP Team,

UNEW is submitting the incoming inspection reports for the capital parts received for refurbishment. Our comments and concerns are based not only on the parts covered in the attached reports but also on components recently received by UNEW and parts visually observed during the recent outage. Across all these groups, we have consistently seen a pattern of **severe deterioration, heavy repair requirements, and limited remaining repair life.**

Based on our inspection results and field observations, many capital parts are in poor condition and require heavy repair. We must be transparent that some of these parts have reached a condition where they would normally be recommended for retirement and replacement with new components. However, we fully understand that NSRP may not have sufficient spare parts available in the warehouse for immediate replacement or for the upcoming inspection and outage requirements. For this reason, UNEW has made every effort to evaluate and save these parts where technically possible, so that NSRP has components available to continue operating the units. Some parts may be repairable for **one more service cycle only,** and this should be carefully factored into future outage planning and spare parts strategy.

The deteriorated condition of these parts is caused by several combined factors, including:

1. Operation under severe thermal and mechanical loading conditions, with frequent starts, shutdowns, emergency trips, and load changes. Each unplanned event subjects components to intense thermal cycling that accelerates wear, cracking, and material degradation over time.
2. Long service history with a high number of accumulated operating hours and repeated refurbishment cycles beyond the original design expectation.
3. Previous repairs were carried out with the primary objective of returning the parts to service for the next operating interval only, rather than fully restoring them to their original design condition. While this approach keeps the unit running in the short term, it means that each successive repair cycle starts from a lower baseline, and the useful life of the parts becomes progressively shorter with every overhaul.
4. Many of the original parts are generic OEM components designed for a broad fleet operating range and are not fully optimised for NSRP's specific fuel composition, refinery environment, and operating profile. Over time, this mismatch accelerates coating breakdown, oxidation, frettage, and dimensional distortion.

For the current refurbishment scope, UNEW will continue to repair and save the existing parts to the maximum extent technically possible. At the same time, we respectfully recommend that NSRP consider the following long-term strategy:

5. Maintain sufficient spare parts inventory for outage and emergency readiness, and plan for the retirement of parts that have reached the end of their practical repair life.
6. For new replacement parts, consider components that are better suited to NSRP's actual operating environment, fuel properties, and thermal cycling conditions rather than standard generic OEM variants.
7. Require future refurbishment work to restore parts to the best technically achievable condition and as close as practical to the original design specification, rather than accepting a minimum standard that only supports the next interval.

8. Track the repair history and remaining repair life of each major capital part to reduce unexpected outage risk and support more effective long-term maintenance planning.

UNEW appreciates NSRP's continued trust and remains available to discuss individual part conditions, repair recommendations, and future replacement planning. We believe it is important to share this technical advice now so that NSRP can plan future refurbishment, replacement, and spare parts requirements more effectively. Please review the attached incoming inspection reports at your earliest convenience.