7. Results of each observation and quantitative evaluation

7-1 Replica・extracted replica observation

(1) Platen SH Outlet Header-Left (Base metal at left side (SA335P12)

(Microstructure observation)

The results of microstructure observation are shown in Photo I -4-1.

The summary of observation results is shown in Table I -4.

- Precipitates at gain boundary were observed in base metal and intercritical zone.

(Grain boundary precipitates observation)

The results of grain boundary precipitates observation are shown in Photo I -4-10.

- Precipitates on grain boundary were observed in base metal and fine grain HAZ.

(Precipitates distribution observation)

The results of precipitates distribution observation are shown in Photo I -4-13.

The summary of observation results is shown in Table I -6.

- Precipitates free zone along grain boundary and attenuated plate-shaped precipitates were observed in base metal.

(2) Platen SH Outlet Header-Left (circumferential weld at left side (SA335P12)

(Microstructure observation)

The results of microstructure observation are shown in Photo I -4-2～6.

The summary of observation results is shown in Table I -4.

- Precipitates at gain boundary were observed in base metal and intercritical zone and fine grain HAZ.
- Rod-shaped precipitates were observed in ferrite grain of base metal.

(Creep void observation)

The results of creep void observation are shown in Photo I -4- 7～9.

The summary of observation results is shown in Table I -5.

- No creep void was observed in fine grain HAZ, coarse grain HAZ and weld metal.

(Grain boundary precipitates observation)

The results of grain boundary precipitates observation are shown in Photo I -4-11～12.

- Precipitates on grain boundary were observed in base metal and fine grain HAZ.

(Precipitates distribution observation)

The results of precipitates distribution observation are shown in Photo I -4-14～17.

The summary of observation results is shown in Table I -6.

- Precipitates free zone along grain boundary and attenuated plate-shaped precipitates were observed in base metal.
- Disintegration of bainite structure was observed in base metal.

(3) De-Suerheater-Left (circumferential weld (SA335P12))

(Microstructure observation)

The results of microstructure observation are shown in Photo I -5-1～5.

The summary of observation results is shown in Table I -4.

- Precipitates at gain boundary were observed in base metal, intercritical zone, fine grain HAZ and coarse grain HAZ.
- Coarse granular precipitates were observed in coarse grain HAZ.

(Creep void observation)

The results of creep void observation are shown in Photo I -5-6～8.

The summary of observation results is shown in Table I -5.

- No creep void was observed in fine grain HAZ, coarse grain HAZ and weld metal.

(Grain boundary precipitates observation)

The results of grain boundary precipitates observation are shown in Photo I -5-9～10.

- Precipitates on grain boundary were observed in base metal and fine grain HAZ.

(Precipitates distribution observation)

The results of precipitates distribution observation are shown in Photo I -5-11～14.

The summary of observation results is shown in Table I -6.

- Attenuated plate-shaped precipitates were observed in base metal.
- Fine precipitates had disappeared in fine grain HAZ.

(4) De-Suerheater-Right (circumferential weld (SA335P12))

(Microstructure observation)

The results of microstructure observation are shown in Photo I -6-1～5.

The summary of observation results is shown in Table I -4.

- Precipitates at gain boundary were observed in base metal, intercritical zone, fine grain HAZ and coarse grain HAZ.
- Coarse granular precipitates were observed in coarse grain HAZ.

(Creep void observation)

The results of creep void observation are shown in Photo I -6-6～8.

The summary of observation results is shown in Table I -5.

- No creep void was observed in fine grain HAZ, coarse grain HAZ and weld metal.

(Grain boundary precipitates observation)

The results of grain boundary precipitates observation are shown in Photo I -6-9～10.

- Precipitates on grain boundary were observed in base metal and fine grain HAZ.

(Precipitates distribution observation)

The results of precipitates distribution observation are shown in Photo I -6-11～14.

The summary of observation results is shown in Table I -6.

- Attenuated plate-shaped precipitates were observed in base metal.
- Fine precipitates had disappeared in weld metal.

(5) RH Outlet Header-Left (circumferential weld at left side (SA335P22))

(Microstructure observation)

The results of microstructure observation are shown in Photo I -7-1～5.

The summary of observation results is shown in Table I -4.

- Precipitates at gain boundary were observed in base metal, intercritical zone, fine grain HAZ and coarse grain HAZ.

(Creep void observation)

The results of creep void observation are shown in Photo I -7-6～8.

The summary of observation results is shown in Table I -5.

- No creep void was observed in fine grain HAZ, coarse grain HAZ and weld metal.

(Grain boundary precipitates observation)

The results of grain boundary precipitates observation are shown in Photo I -7-9～10.

- Precipitates on grain boundary were observed in base metal and fine grain HAZ.

(Precipitates distribution observation)

The results of precipitates distribution observation are shown in Photo I -7-11～14.

The summary of observation results is shown in Table I -6.

- No remarkable degradation of precipitates distribution was observed.

(6) RH Outlet Header-Right (circumferential weld at right side (SA335P22))

(Microstructure observation)

The results of microstructure observation are shown in Photo I -8-1～5.

The summary of observation results is shown in Table I -4.

- Precipitates at gain boundary were observed in base metal, intercritical zone and fine grain HAZ.
- Precipitates free zone along grain boundary was observed in base metal.

(Creep void observation)

The results of creep void observation are shown in Photo I -8-6～8.

The summary of observation results is shown in Table I -5.

- No creep void was observed in fine grain HAZ, coarse grain HAZ and weld metal.

(Grain boundary precipitates observation)

The results of grain boundary precipitates observation are shown in Photo I -8-9～10.

- Precipitates on grain boundary were observed in base metal and fine grain HAZ.

(Precipitates distribution observation)

The results of precipitates distribution observation are shown in Photo I -8-11～14.

The summary of observation results is shown in Table I -6.

- Precipitates free zone along grain boundary was observed in base metal.
- No remarkable degradation of precipitates distribution was observed.
- Fine precipitates had disappeared in fine grain HAZ, coarse grain HAZ and weld metal.

(7) Main Steam Pipe-Left (Circumferential weld, extrados (SA335P22))

(Microstructure observation)

The results of microstructure observation are shown in Photo I -9-1～5.

The summary of observation results is shown in Table I -4.

- Precipitates at gain boundary were observed in base metal, intercritical zone, fine grain HAZ and coarse grain HAZ.
- Precipitates free zone along grain boundary was observed in base metal and intercritical zone.

(Creep void observation)

The results of creep void observation are shown in Photo I -9-6～8.

The summary of observation results is shown in Table I -5.

- No creep void was observed in fine grain HAZ, coarse grain HAZ and weld metal.

(Grain boundary precipitates observation)

The results of grain boundary precipitates observation are shown in Photo I -9-9～10.

- Precipitates on grain boundary were observed in base metal and fine grain HAZ.

(Precipitates distribution observation)

The results of precipitates distribution observation are shown in Photo I -9-11～14.

The summary of observation results is shown in Table I -6.

- Precipitates free zone along grain boundary was observed in base metal.

(8) Main Steam Pipe-Left (Circumferential weld, intrados (SA335P22))

(Microstructure observation)

The results of microstructure observation are shown in Photo I -10-1～5.

The summary of observation results is shown in Table I -4.

- Precipitates at gain boundary were observed in base metal, intercritical zone and fine grain HAZ.
- Precipitates free zone along grain boundary was observed in base metal and intercritical zone.

(Creep void observation)

The results of creep void observation are shown in Photo I -10-6～8.

The summary of observation results is shown in Table I -5.

- No creep void was observed in fine grain HAZ, coarse grain HAZ and weld metal.

(Grain boundary precipitates observation)

The results of grain boundary precipitates observation are shown in Photo I -10-9～10.

- Precipitates on grain boundary were observed in base metal and fine grain HAZ.

(Precipitates distribution observation)

The results of precipitates distribution observation are shown in Photo I -10-11～14.

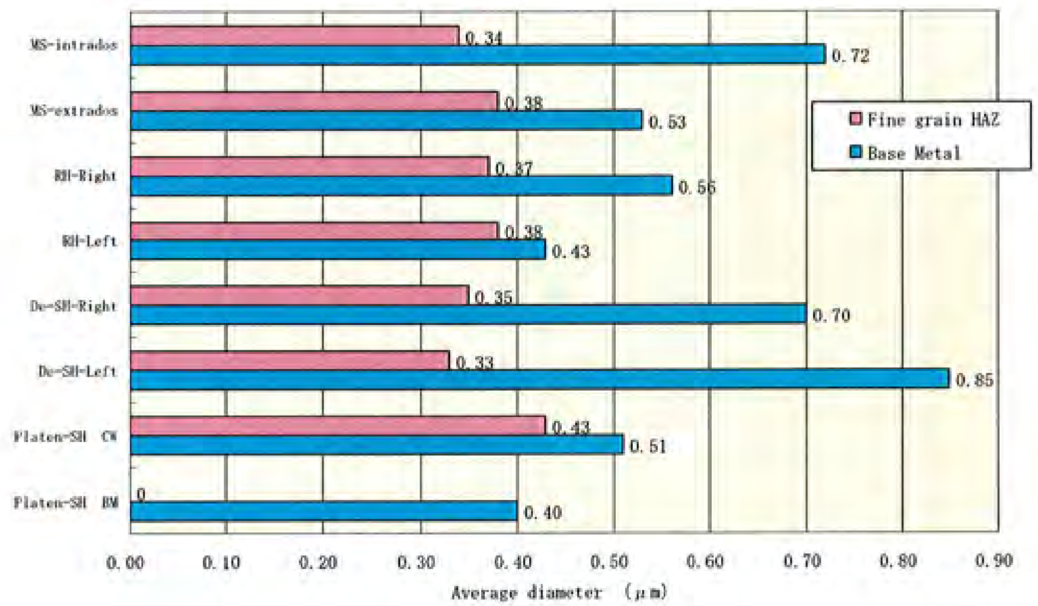
The summary of observation results is shown in Table I -6.

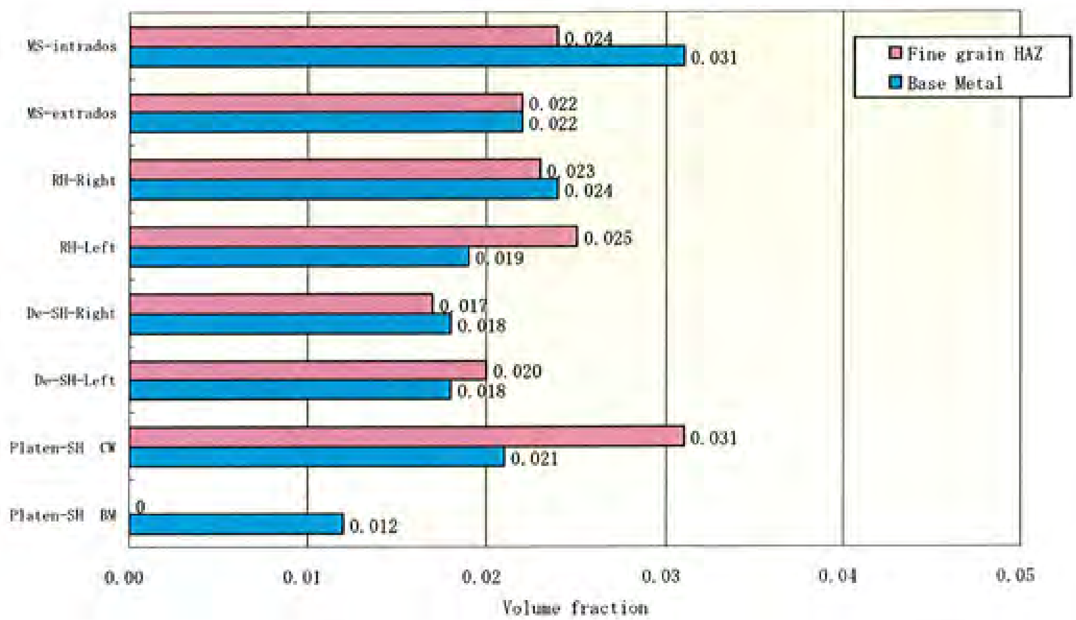
- Precipitates free zone along grain boundary was observed in base metal.
- Fine precipitates had disappeared in fine grain HAZ, coarse grain HAZ and weld metal.

7-2 Quantitative evaluation of grain boundary precipitates

The results of quantitative evaluation of grain boundary precipitates are shown in Table I -7.

- The Max. value of average diameter of grain boundary precipitates was 0.85 μ m in base metal at De-Superheater-Left, 0.43 μ m in fine grain HAZ at Platen-SH Outlet Header-Left circumferential weld.
- The max. value of volume fraction of grain boundary precipitates was 0.031 in base metal at Main Steam Pipe-Intrados, 0.031 in fine grain HAZ at Platen-SH Outlet Header-Left circumferential weld.



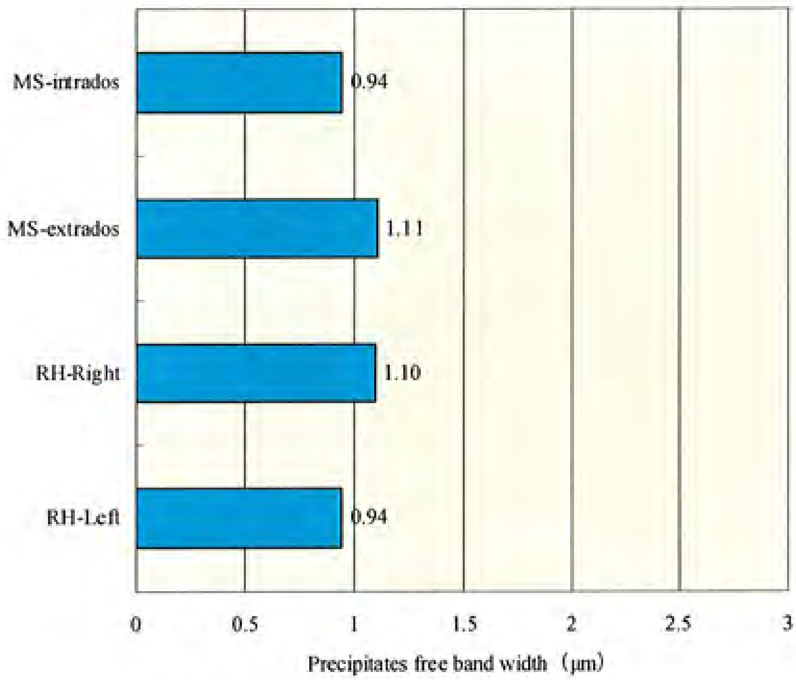


Quantitative evaluation of grain boundary precipitates〔extracted Table I -7〕

7-3 Quantitative evaluation of precipitates free band width along grain boundary

The results of quantitative evaluation of precipitates free band width along grain boundary are shown in Table I -8.

- The quantitative evaluation was focused on base metal of SA 335 P22.
- The Max. value of precipitates free band width along grain boundary was 1.11 μ m at Main Steam Pipe-Extrados.



Precipitates free band width along grain boundary〔extracted Table I -8〕

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8. Residual life assessment results

8-1 Operational condition of evaluated components

Operational condition of evaluated components are shown in Table I -9.

The evaluation stress σ was the hoop stress calculated with designed pressure, designed diameter D and thickness t of each component.

$$\sigma = P(D-t)/2t$$

where P : Designed pressure.

8-2 Evaluation results

Evaluation results of residual life assessment for each components by microstructural comparison method are shown in Evaluation Results I -1～7 and Table I -10. The summary of evaluation results are shown in Table I -11

- The high creep life consumption ratio was evaluated at Main Steam Pipe-Left with high evaluation stress portion.
- The creep life consumption ratio was 70% and the evaluated residual life was 37,000 hours at Main Steam Pipe-Left (Circumferential weld, extrados) with microstructural degradation that was observed as precipitates free zone along grain boundary in base metal.
- The creep life consumption ratio was 80% and the evaluated residual life was 21,000 hours at Main Steam Pipe-Left (Circumferential weld, intrados) with microstructural degradation that was observed as disappearance of fine needlelike precipitates.
- For the other components, the highest creep life consumption ratio was 45% and the evaluated residual life was 100,000 hours at De-Superheater (Left&Right).
- It is recommended that the residual life assessment for Main Steam Pipe is carried out again before reaching the evaluated residual life.

Table I -11 Summary of residual life evaluation results

Components	Location	Max. creep life consumption ratio (%)	Min. Evaluated residual life (h)	Evaluated region
Platen SH Outlet Header-Left	Circumferential weld at left side	38	140,000	Fine grain HAZ
De-Superheater-Left	Circumferential weld	45	100,000	Coarse grain HAZ
De-Superheater-Right	Circumferential weld	45	100,000	Coarse grain HAZ
RH Outlet Header-Left	Circumferential weld at left side	20	340,000	Coarse grain HAZ
RH Outlet Header-Right	Circumferential weld at right side	6	1,300,000	Base Metal
Main Steam Pipe-Left	Circumferential weld,extrados	70	37,000	Base Metal
Main Steam Pipe-Left	Circumferential weld,intrados	80	21,000	Fine grain HAZ

9. The other inspection results

9-1 Visual inspection, Thickness measurement

Visual inspection results for boiler inside are shown in Table I -12

(Erosion of water wall around short soot blower)

- Erosion by soot blower was observed at a number of Water wall tubes around short soot blower.
- The thickness measurement was carried out at the representative eroded portion (2^{nd} short soot blower level) as shown in Table I -13～16.
- Min.thickness was 3.7mm at a front wall tube around #1 short soot blower from right, that was less than tsr (thickness required) 5.5mm calculated with designed OD, pressure and allowable stress at the designed temperature.

Erosion of front wall tube
〔extracted from Table I -12〕

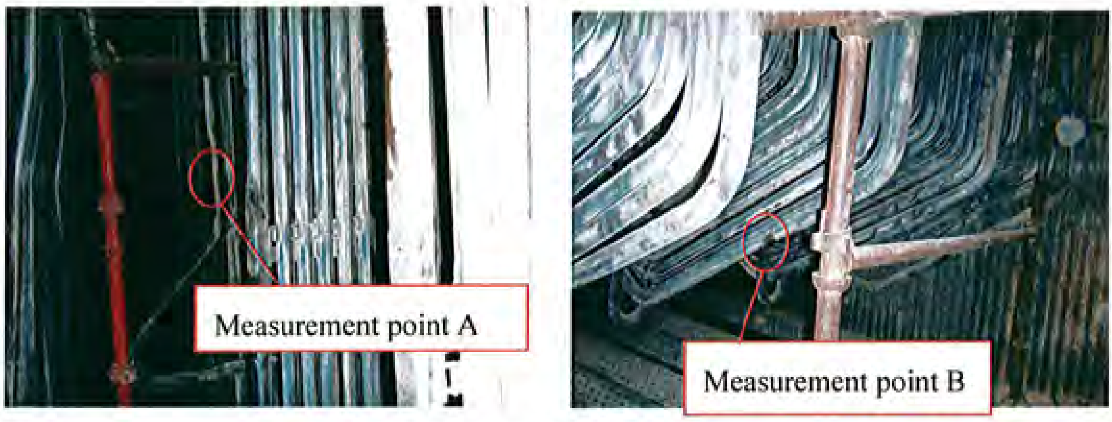
(Attrition of Platen-SH binding tube #4 and #5

- Attrition of binding tube #4 and #5 with each other was found.
- The thickness measurement results are shown in Table I -17.
- Min.thickness was 2.8mm, that was far less than the designed value 6.5mm.

Attrition of binding tube 〔extracted from Table I -12〕

(Thickness measurement of Platen-SH)

- Thickness was measured mainly for outer tubes of rear side portion at soot blower level and outer bottom tubes as shown in Table I -18.
- Min.thickness at soot blower level (measurement point A) was 6.3mm, that was not less than the designed value 6.3mm.
- Min.thickness at outer bottom tubes (measurement point B) was 9.8mm, that was larger than the designed value 9.5mm.



Thickness measurement portion of Platen-SH 〔extracted Table I -18〕

(Attrition of cooling spacer tube with Platen-SH front tube of #14 panel)

- Attrition of a cooling spacer tube with Platen-SH front tube of #14 panel.
- The thickness measurement results are shown in Table I -17.
- Min.thickness was 5.0mm.

Attrition of cooling spacer tube〔extracted Table I -12〕

(Erosion of screen tubes near the ceiling between front RH panel and rear RH panel)

- Erosion of screen tubes at front side near the ceiling was found at left side of boiler.

Erosion of rear wall screen tubes〔extracted Table I -12〕

9-2 OD measurement results

OD measurement results of residual life evaluated portion are shown in Table I -19～22.

- The increase in measured average OD to designed value was less than 1% for each portion, indicating no remarkable creep strain.

Table I -23 OD measurement results of each portion

(Increase in measured average OD to designed value)

Components	Location	Material	(Averaged measured value-Designed OD) /Designed OD(%)
Platen SH Outlet Header-Left	Circumferential weld at left side	SA335P12	0.10
De-Superheater-Left	Circumferential weld	SA335P12	0.94
De-Superheater-Right	Circumferential weld	SA335P12	0.55
RH Outlet Header-Left	Circumferential weld at left side	SA335P22	0.37
RH Outlet Header-Right	Circumferential weld at right side	SA335P22	0.52
Main Steam Pipe-Left	Circumferential weld,extrados	SA335P22	0.08
Main Steam Pipe-Left	Circumferential weld,intrados	SA335P22	

9-3 SUS scale deposition inspection

Applied equipment and inspection condition are shown in Table I -24.

SUS scale deposition inspection were carried out at outer most tube bend portion and binding tube bottom bend portion of Platen-SH and RH as shown in Fig. I -2.

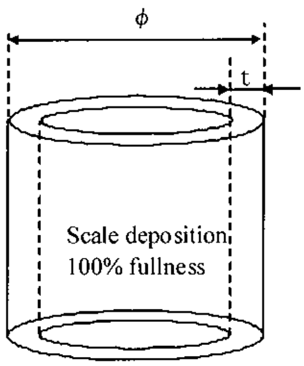
Table I -24 Applied equipment and inspection condition

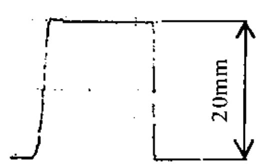
DETECTOR	MAKER・TYPE	UNI-ELECTRONICS,Inc. ・SSD－1
	I.D.№	34A3382(64SCA02101)
	CHECK DATE・PERSON	2009 June 5th ・Shinichi Aizawa
	VAIDITY DATE	2010 June 4th
RECORDER	MAKER・TYPE	HIOKI E. E. CORPORATION ・8205-10
	I.D.No.	041213164(64SCZ05102)
	CHECK DATE・PERSON	2009 May 28th ・Shinichi Aizawa
	VAIDITY DATE	2010 May 27th ・Shinichi Aizawa

INSPECTION METHOD	Magnetized scale deposition inspection of tube inside with scale detector
INSPECTION METHOD	Refer to next page
SENSITIVITY LEVEL	The sensitivity is adjusted at 20mm in amplitude of signal with the probe touching right to the reference test piece filled with the white magnetic particle 100% fullness.
SCANNING SPEED	Approx. 0.3m/sec
RECORDING RANGE	1V/cm
RECORDING SPEED	2.5mm/sec
REFERENCE TEST PIECE	Platen SH outer most tube bend portion : ϕ 54.0× t 9.5 (I.D. No. : 50-21-1) Platen SH binding tube bottom bend portion : ϕ 47.6× t 6.3 (I.D. No : 40-14-1) RH outer most tube bend portion : ϕ 54.0× t 4.0 (I.D. No : 50-19-1) RH binding tube bottom bend portion : ϕ 54.0× t 4.0 (I.D. No : 50-19

REMARKS

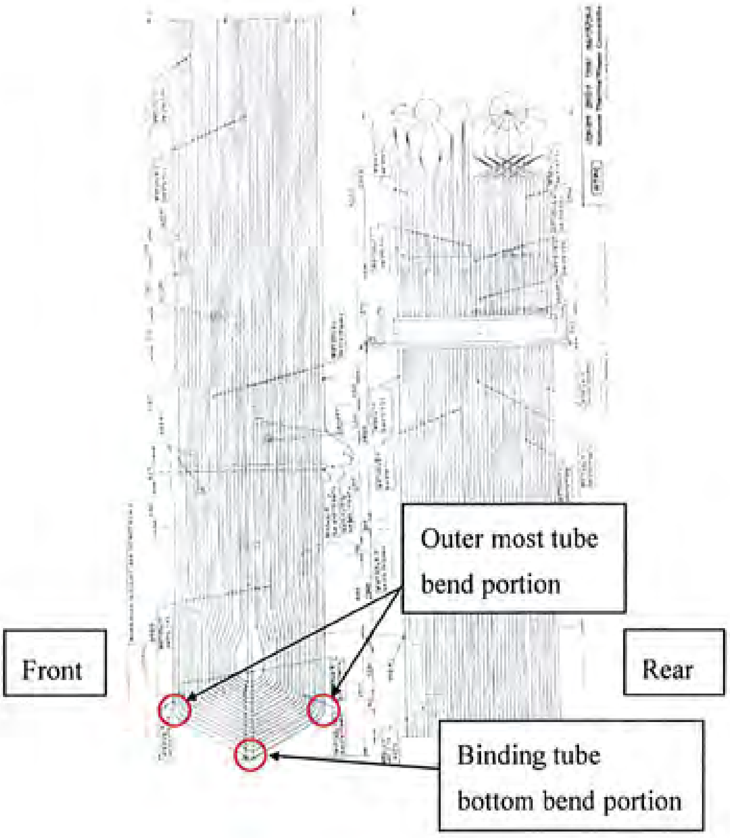
Shape of reference test piece and wave form





Wave form
by reference test piece

Platen-SH



RH

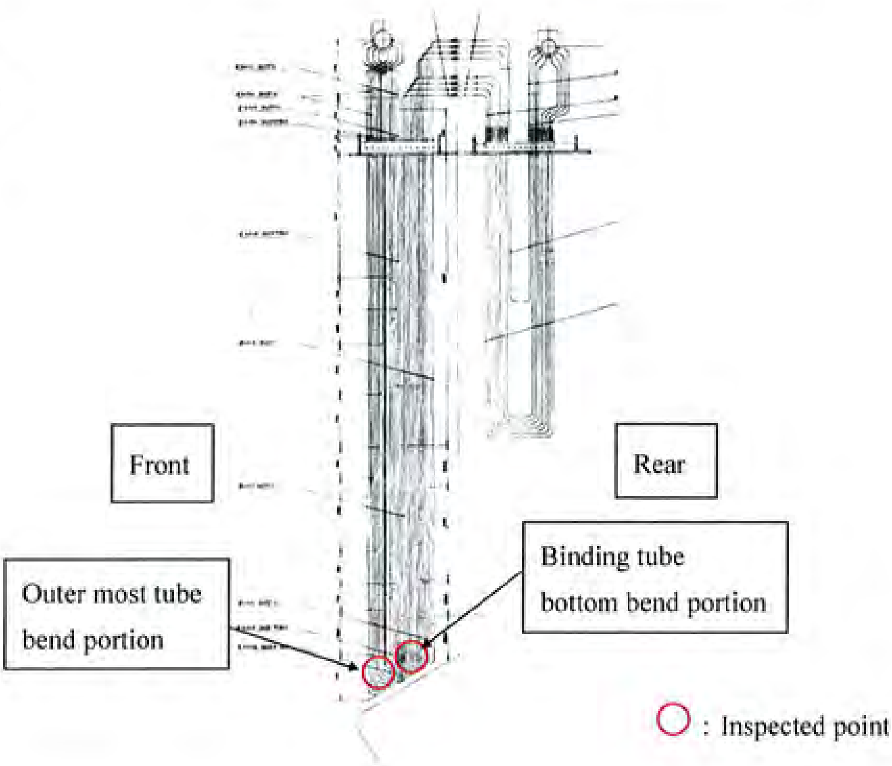


Fig. I -2 Inspection location

SUS scale deposition inspection results are shown in Table I -25.

- 15% fullness of SUS scale deposition was detected at 4 outermost tubes of Platen-SH and 1 outermost tube of RH.
- 10% % fullness of SUS scale deposition was detected at 3 outermost tubes of Platen-SH.
- The others were less than 10% fullness of SUS scale deposition.

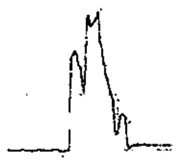
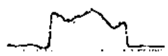
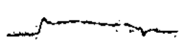
Table I -25 SUS scale deposition inspection results

Platen SH (outermost tube)				RH (outermost tube)	
Front		Rear		Front	
Panel No.	Fullness (%)	Panel No.	Fullness (%)	Panel No.	Fullness (%)
14	15	6	15	3	15
20	10	13	10		
21	15	18	10		
		21	15		

〔Remarks〕

The signal by magnetization of tube material with heat was recognized at front side outermost tubes in Platen-SH except #1,2,5,7～11 panel from left and at rear side tubes in Platen-SH except #7～11 from left.

The representative deposition signal for this inspection is shown in Fig. I -3. The standard curve used is shown in Fig. I -4.

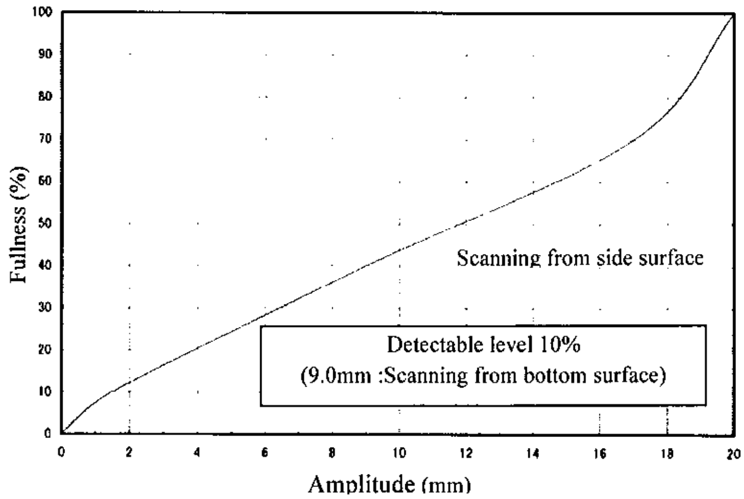
	Scanning from bottom surface	Scanning from side surface
Platen SH outermost tube front bend portion #14 panel Fullness 15%		
Platen SH binding tube bottom bend portion #18 panel Fullness 0%		
RH outermost tube front bend portion # 3 panel Fullness 15%		
RH binding tube bottom bend portion #5 panel- a Fullness 0%		

Note) "a" indicates front tube in RH binding tubes,

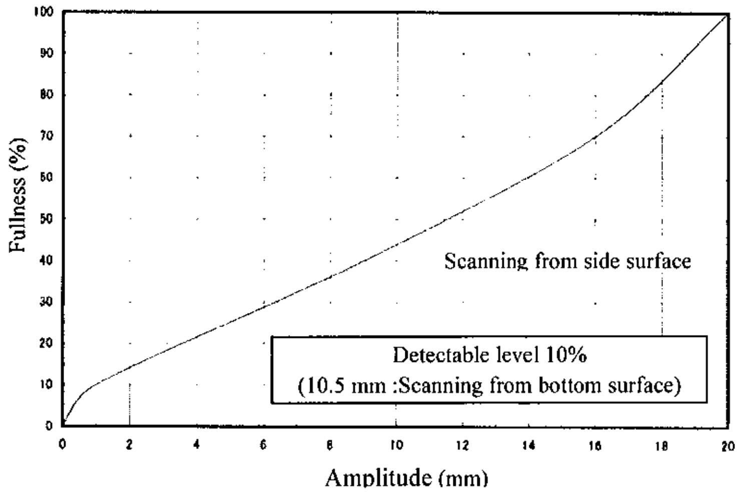
Fig. I -3 The representative deposition signal

Fig. I -3 Representative deposition signal for this inspection

Standard curve (ϕ 54.0× t 9.5mm)



Standard curve (ϕ 47.6× t 6.3mm)



Standard curve (ϕ 54.0× t 4.0mm)

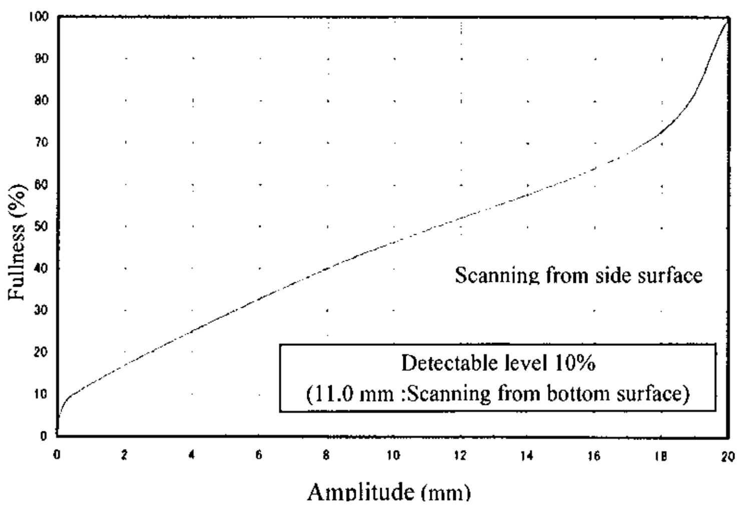


Fig. I -4 Standard curve used for evaluation

9-4 DPT

Applied material and inspection condition are shown in Table I -26.

Inspected location of DPT is shown in Fig. I -5.

DPT inspection were carried out at 4 stub weld portions of #5 panel from left in Platen SH inlet header front side.

Table I -26. Applied material and inspection condition

APPLIED MATERIAL

APPLIED MATERIAL	PENETRANT	BRAND	Eishin Kagaku Co., Ltd.
		MAKER	R-1A (NT)
	REMOVER	BRAND	Eishin Kagaku Co., Ltd.
		MAKER	R-1S (NT)
	DEVELOPER	BRAND	Eishin Kagaku Co., Ltd.
		MAKER	R-1M (NT)

EXAMINATION CONDITION

EXAMINATION METHOD	Liquid penetrant with removability for solvents - Drying development method
TIME TO EXAMINATION	at periodic inspection
TEMPERATURE OF EXAMINATION SURFACE	Normal temperature (10～50℃)
EXAMINATION SURFACE CONDITION	As weld
PRE-TREATMENT	■Rinse with solvents □Others ( )
PENETRATION METHOD	■Spray □Brush painting □Dipping □Others ( )
PENETRATION TIME	10 minutes
REMOVING OF EXTRA PENETRANT	■Wipe out with wes (using solvent) □Others ( )
DEVELOPMENT METHOD	■Spray □Brush painting □Dipping □Others ( )
DEVELOPMENT TIME	10 minutes
ILLUMINANCE OF EXAMINATION SURFACE／ILLUMINANCE OF ENVIRONMENT	500Lux or more

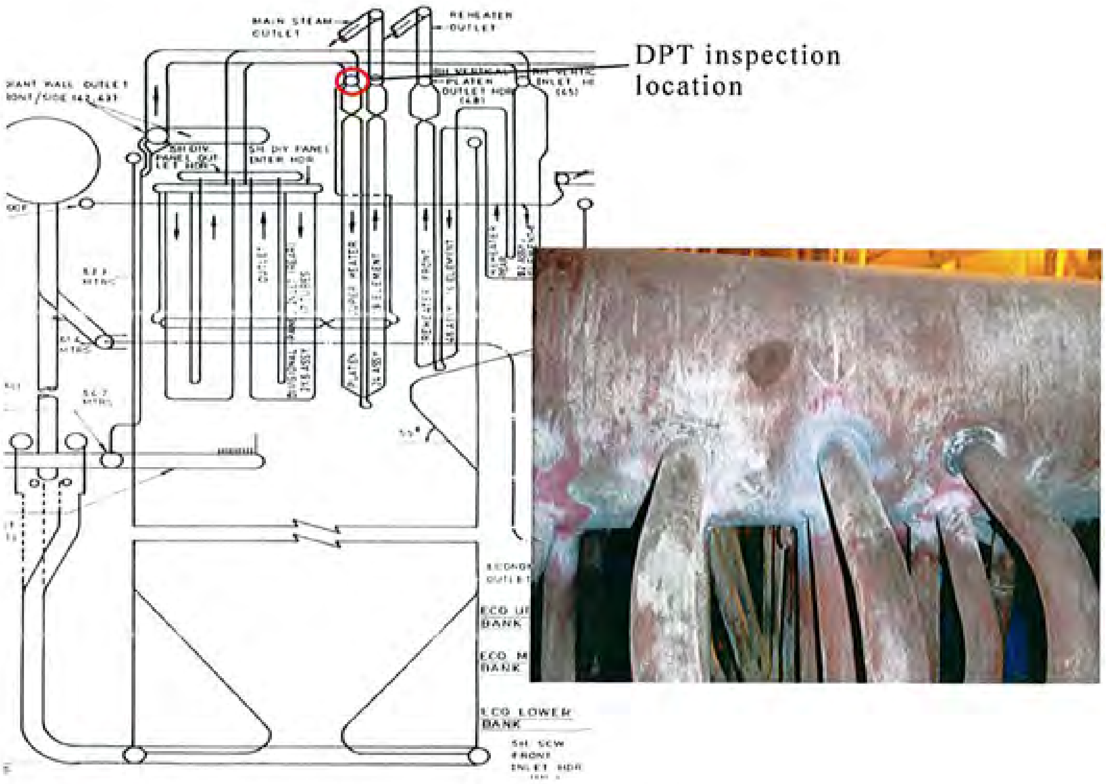


Fig. I -5 DPT inspection location

An indication with 2mm in length was found in 3rd stub weld portion from front. The indication disappeared after grinding off the tube 1mm in depth.

Before grinding off

After grinding off

9-5 UT

Applied equipment and inspection condition are shown in Table I -27.

Inspected location of UT is shown in Fig. I -6.

UT inspection was carried out at circumferential weld of left RH outlet header.

Table I -27 Applied equipment and inspection condition

APPLIED EQUIPMENT AND MATERIAL

FLAW DETECTOR	MAKER・TYPE	GE INSPECTION TECHNOLOGIES ・ USM35X		
	SERIAL No.(I.D.№)	994a(61UAA06110)		
	AMPLITUDE LINEARITY	within ±3%		
	TIME SCALE LINEARITY	within ±1%		
	MARGIN OF DETECTION SENSITIVITY	40dB or more		
	CHECK DATE・PERSON	2008 November 20th ・ Hidekazu Ishihara(UT-2)		
	VAIDITY DATE	2009 November 19th		
PROBE	TYPE	angle beam probe		
	DESIGNATION	2C14×14A70		
	MAKER	KGK		
	SERIAL No.	XA7424		
	DEAD ZONE	18mm		
	STB ANGLE OF REFRACTION	70 degree		
	ACCESIBLE LIMIT DISTANCE	17mm		
	FAR SURFACE RESOLUTION	7mm		
	CHECK DATE・PERSON	2009 August 26th Ishizaki (UT-2)		
	VAIDITY DATE	2010 February 25th		

EXAMINATION CONDITION

EXAMINATION METHOD	Single angle beam probe technique
TIME TO EXAMINATION	at periodic inspection
SURFACE CONDITION	Grinded surface
COUPLANT	Sonicoat
SPECIFIED SENSITIVITY	RB-41 №2 ϕ 3.0mm side cylindrical hole: H-line
SENSITIVITY CORRECTION	Non
DISREGARD LEVEL	Regarded as flaw that echo hight is over DAC(H-line)
ACCEPTANCE CRITERIA	Flaw length with t/3 or less
REFERENCE BLOCK OR CALIBRATION BLOCK	RB-41 №2
ANGLE OF REFRACTION IN TEST OBJECT	ANGLE OF REFRACTION : – CALCULATION METHOD : ☐Ratio of sound velocity of STB ☐ V path technique

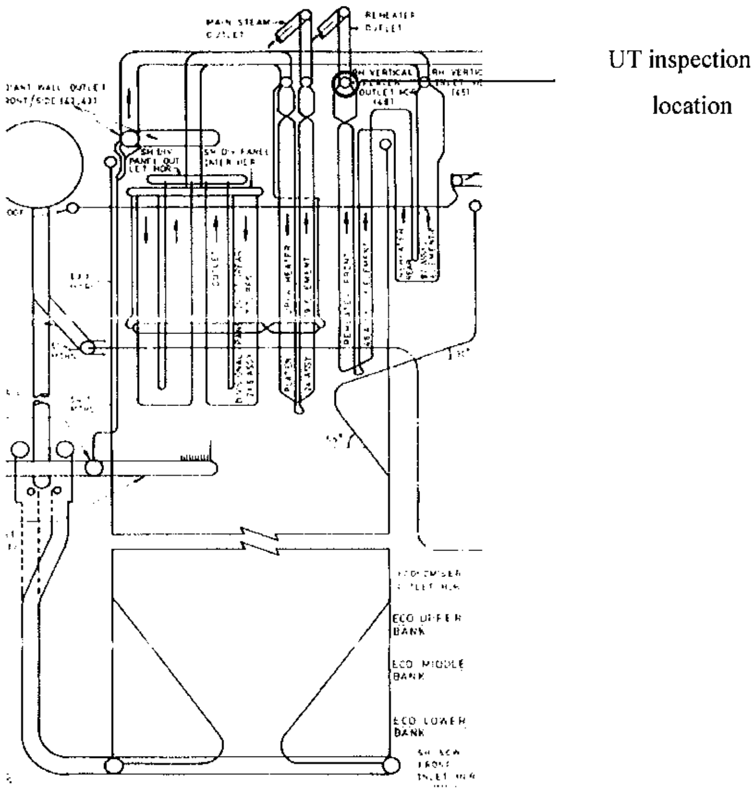


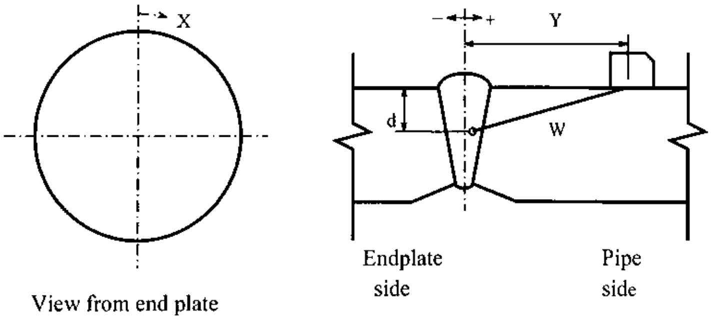
Fig. I -6 Inspected location of UT

UT detection results are shown in Table I -28.

No flaw echo exceeded criteria was detected, although 4 flaws exceeded L-line were detected as shown in Table I -28. In Table I -28, symbols are described in the figure shown below.

Table I -28 Detected flaw list

Flaw №	X	Y	W	d	k	Region of echo height	l
1	582	93	104.6	37.5	-4.7	II	10
2	820	122	129.2	46.3	1.4	III	34
3	940	51	26.8	9.6	26	II	6
4	1110	101	101.3	36.3	6.4	II	8



9-6 TOFD

Applied equipment and inspection condition are shown in Table I -29.

Table I -29 Applied equipment and inspection condition

APPLIED EQUIPMENT AND MATERIAL

FLAW DETECTOR	MAKER・TYPE	OLYMPUS NDT μ-Tomoscan
	SERIAL No.(I.D.№)	23918-15(71UAA96105)
PROBE	DESIGNATION	5MHz、 φ 1/4inch
	WEDGES	60°
	MAKER	GE INSPECTION TECHNOLOGIES
	SERIAL No.	00CP4M,00B25K

EXAMINATION CONDITION

EXAMINATION METHOD	TOFD technique
TIME TO EXAMINATION	at periodic inspection
SURFACE CONDITION	Grinded surface
COUPLANT	Sonicoat
SPECIFIED SENSITIVITY	φ 4.8mm side cylindrical hole ((d=40mm):80%+6dB
SENSITIVITY CORRECTION	Non
DISREGARD LEVEL	――――――

TOFD inspection was carried out at the location identical to UT inspection.

The range of X : 300～600mm and 900～1200mm in circumferential direction was not detectable because of the interference of attached objects.

TOFD detection results are shown in Fig. I -7～10.

No flaw echo judged as a crack was detected, although a number of flaw echoes from subtle blow holes and slag inclusions by welding were detected.

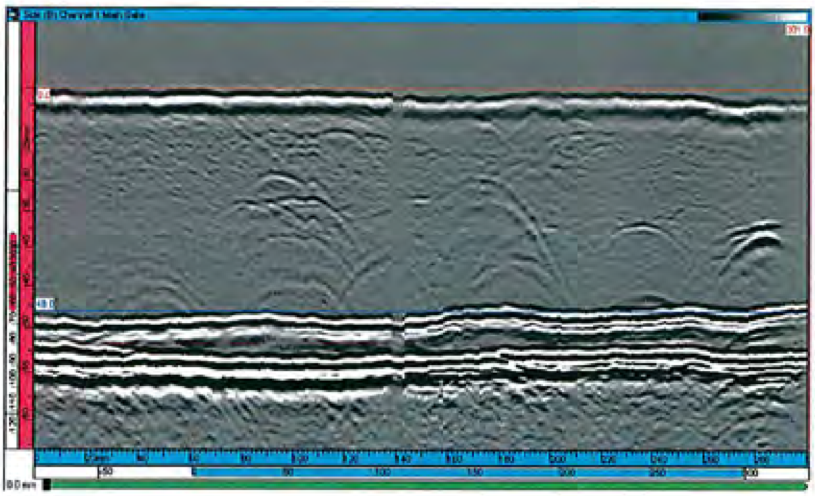


Fig. I -7 X=0～300mm TOFD detection results

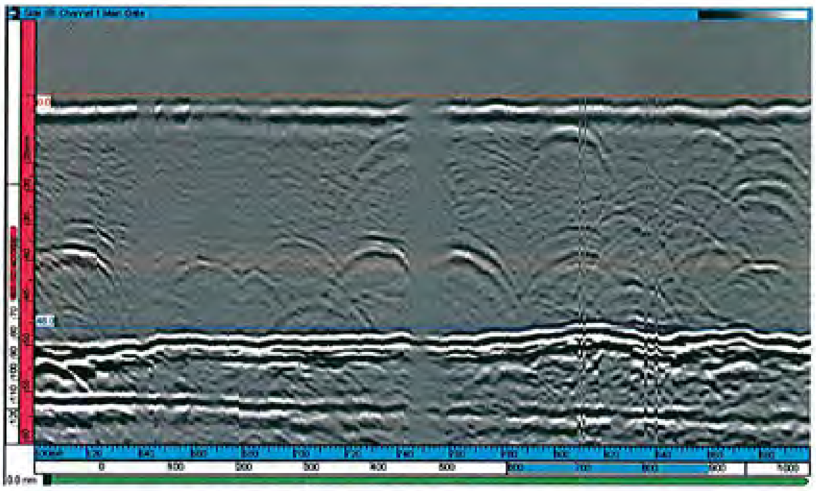


Fig. I -8 X=600～900mm TOFD detection results

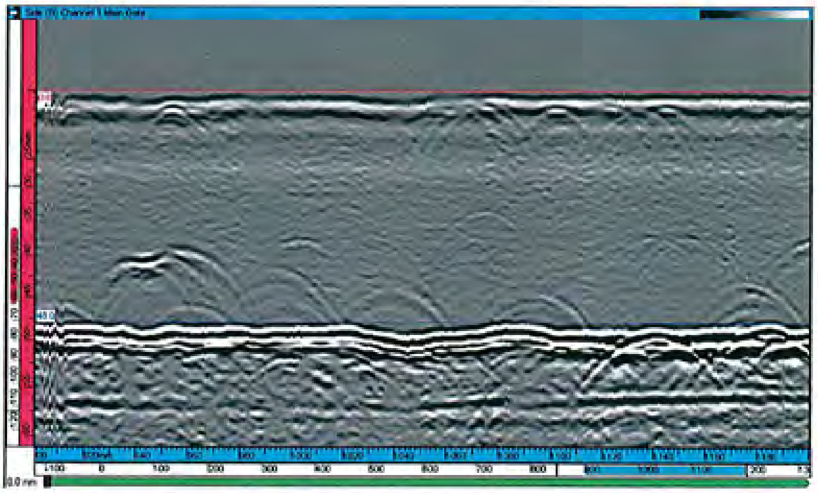


Fig. I -9 X=1200～1500mm TOFD detection results

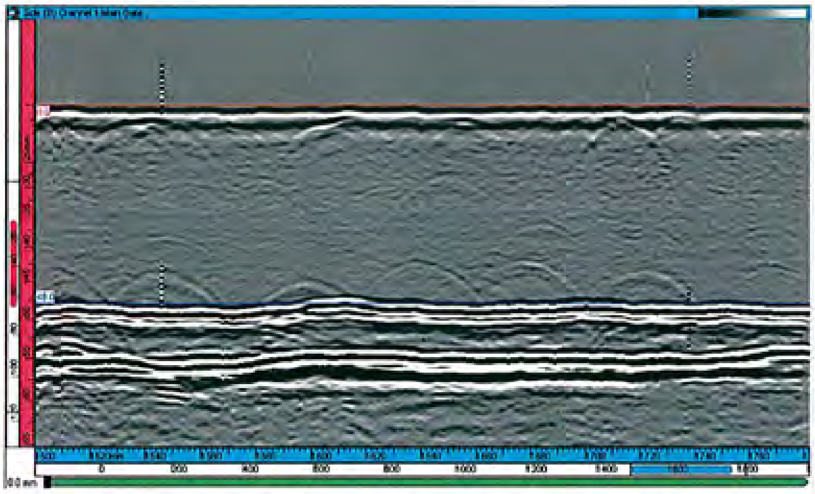
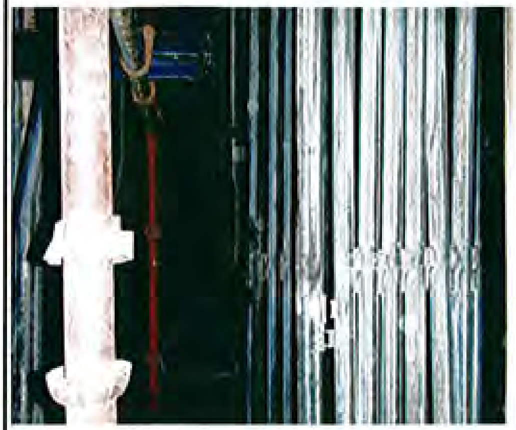


Fig. I -10　X=1500～1780mm TOFD detection

Water wall around short soot blower

・Visual inspection ・Thickness measurement

Platen SH at soot blower level

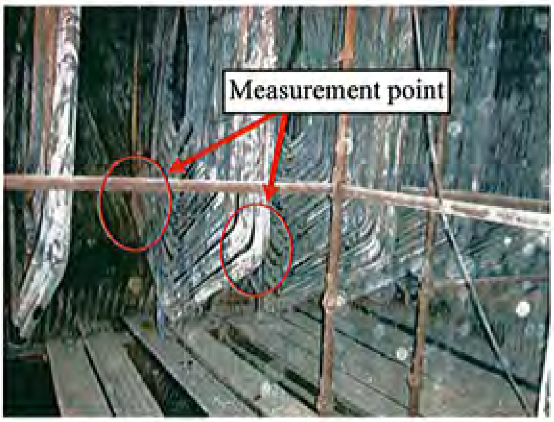


・Visual inspection ・Thickness measurement

Platen SH tube sampling location

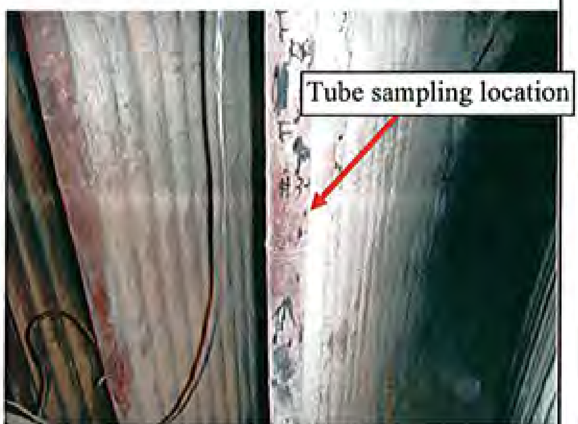
・Sample tube inspection
・Creep rupture test

Platen SH SUS scale mesurement point



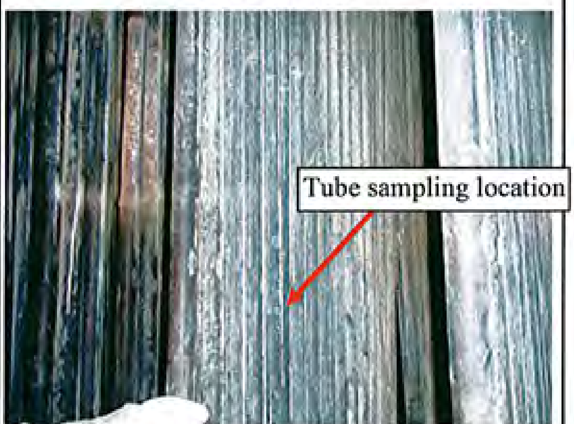
・SUS scale deposition inspection

RH(in penthouse) tube sampling location



・Sample tube inspection
・Creep rupture test

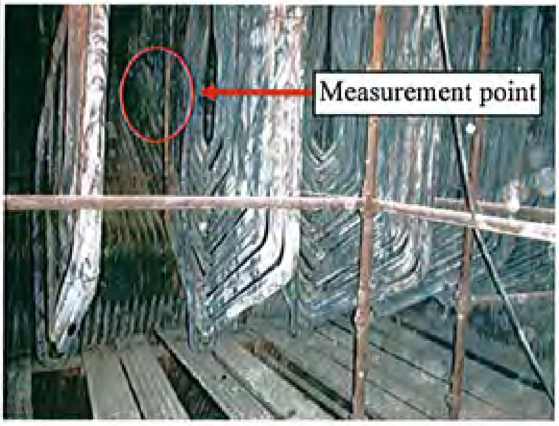
RH(in furnace) tube sampling location



・Sample tube inspection
・Creep rupture test

Photo I -1 Inspection location

RH SUS scale mesurement point

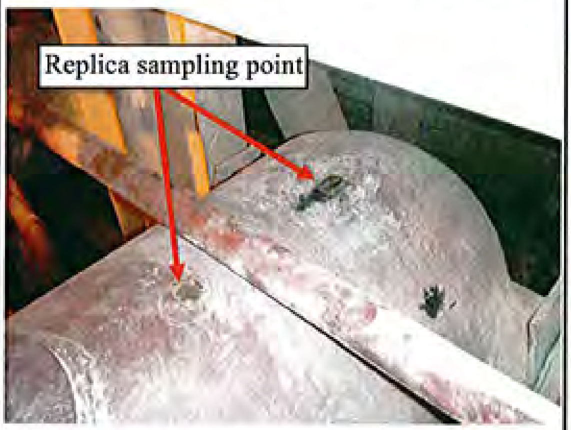


・SUS scale deposition inspection

Platen SH Inlet Header

・DPT

Platen SH Outlet Header(Boiler left side)

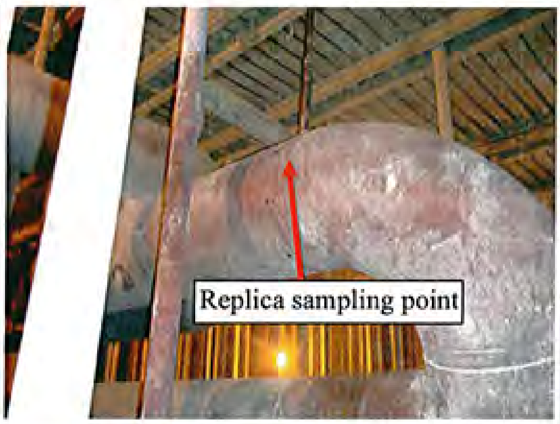


・Replica inspection ・OD measurement

De-superheater(Boiler left side)

・Replica inspection ・OD measurement

De-superheater(Boiler right side



・Replica inspection ・OD measurement

RH Outlet header(Boiler left side

・Replica inspection ・OD measurement

Photo I -2 Inspection location

RH Outlet header(Boiler right side)

・Replica inspection ・OD measurement
・UT ・TOFD

Main Steam Pipe-Left (extrados)

・Replica inspection ・OD measurement

Main Steam Pipe-Left (intrados)

・Replica inspection ・OD measurement

Photo I -3 Inspection location

Table I -4 Microstructure observation resuluts

Components	Location		Observed region	OM (Optical microscope observation)					
				Microstructural features					
				Precipitation at gain boundary	Precipitates free zone along grain boundary	Granular precipitates in ferrite grain	Rod-shaped precipitates in ferrite grain	Granular precipitates	Coarse granular precipitates
Platen SH outlet header (SA 335 P12)	Left outlet header	Base metal	Base metal	Appeared	Not appeared	No precipitation	Not appeared		
		Circumferential weld	Base metal	Appeared	Not appeared	No precipitation	Not appeared		
			Intercritical zone	Appeared				Appeared	Not appeared
			Fine grain HAZ	Appeared					Not appeared
			Coarse grain HAZ	Not appeared					Not appeared
			Weld metal					Appeared	
De-Superheater pipe (SA 335 P12)	Left de superheater	Circumferential weld	Base metal	Appeared	Not appeared	No precipitation	Not appeared		
			Intercritical zone	Appeared				Appeared	Not appeared
			Fine grain HAZ	Appeared					Not appeared
			Coarse grain HAZ	Appeared					Appeared
			Weld metal					Appeared	
	Right de superheater	Circumferential weld	Base metal	Appeared	Not appeared	No precipitation	Not appeared		
			Intercritical zone	Appeared				Appeared	Not appeared
			Fine grain HAZ	Appeared					Not appeared
			Coarse grain HAZ	Not appeared					Appeared
			Weld metal					Appeared	
Reheater outlet header (SA 335 P22)	Left	Circumferential weld	Base metal	Appeared	Not appeared				
			Intercritical zone	Appeared	Not appeared				
			Fine grain HAZ	Appeared					
			Coarse grain HAZ	Appeared					
			Weld metal						
	Right	Circumferential weld	Base metal	Appeared	Appeared				
			Intercritical zone	Appeared	Not appeared				
			Fine grain HAZ	Appeared					
			Coarse grain HAZ	Not appeared					
			Weld metal						
Main steam pipe (SA 335 P22)	Left	Circumferential weld (near the stop valve) extrados side	Base metal	Appeared	Appeared				
			Intercritical zone	Appeared	Appeared				
			Fine grain HAZ	Appeared					
			Coarse grain HAZ	Appeared					
			Weld metal						
		Circumferential weld (near the stop valve) intrados side	Base metal	Appeared	Appeared				
			Intercritical zone	Appeared	Appeared				
			Fine grain HAZ	Appeared					
			Coarse grain HAZ	Not appeared					
			Weld metal						
View nos. for each area				×500 (2 views) ×1000 (4 views)					

Table I -5 Creep void observation results

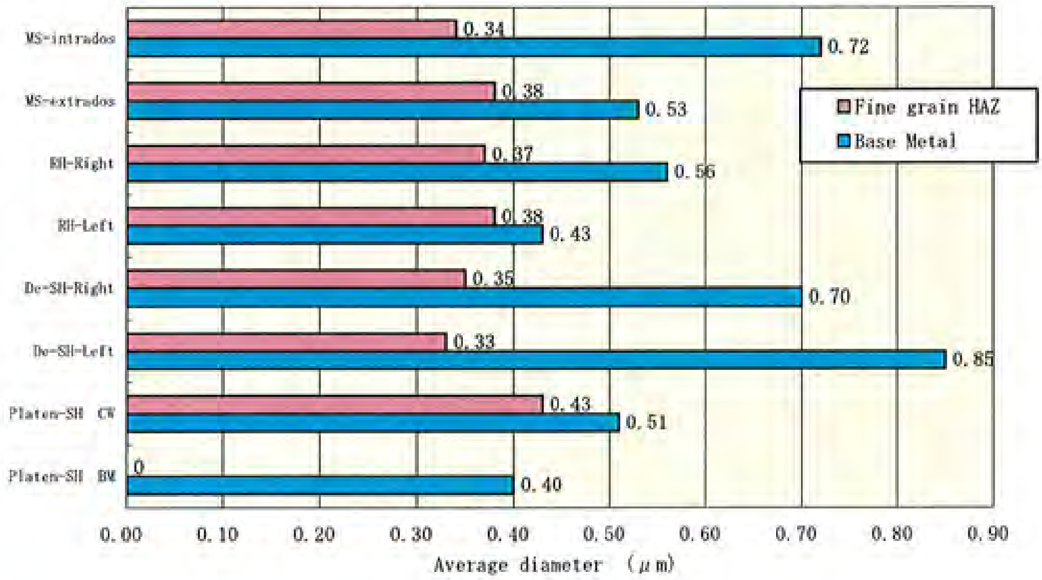
Components	Location		Observed region	SEM (Scanning Electron Microscope observation) Ceep void damage
Platen SH outlet header	Left outlet header	Circumferential weld	Fine grain HAZ	No void
			Coarse grain HAZ	No void
			Weld metal	No void
De-Superheater pipe	Left de superheat	Circumferential weld	Fine grain HAZ	No void
			Coarse grain HAZ	No void
			Weld metal	No void
	Right de superhea	Circumferential weld	Fine grain HAZ	No void
			Coarse grain HAZ	No void
			Weld metal	No void
Reheater outlet header	Left	Circumferential weld	Fine grain HAZ	No void
			Coarse grain HAZ	No void
			Weld metal	No void
	Right	Circumferential weld	Fine grain HAZ	No void
			Coarse grain HAZ	No void
			Weld metal	No void
Main steam pipe	Left	Circumferential weld (near the stop valve) extrados side	Fine grain HAZ	No void
			Coarse grain HAZ	No void
			Weld metal	No void
		Circumferential weld (near the stop valve) extrados side	Fine grain HAZ	No void
			Coarse grain HAZ	No void
			Weld metal	No void
View nos. for each area				×500 (3 views) ×2000 (3 views)

Table I -6 Precipitates distribution observation results

Components	Location		Observed region	TEM (Transmission Electron Microscope observation) Precipitates features: Precipitates free zone along grain boundary	Featherlike precipitates	Fine needlelike and granular precipitates	Needlelike precipitates	Fine needlelike and granular precipitates in bainite grain	Bainite structure disintegration	Attenuated plate-shaped precipitates	Rod-shaped precipitates, spherodized precipitates
Platen SH outlet header (SA 335 P12)	Left outlet header	Base metal	Base metal	Appeared		Remaining in ferrite grain			Disintegrated	Appeared	
		Circumferential weld	Base metal	Not appeared		Remaining in ferrite grain			Disintegrated	Not appeared	
			Fine grain HAZ			Remaining				Not appeared	Coexist
			Coarse grain HAZ			Remaining					Coexist
			Weld metal			Remaining					
De-Superheater pipe (SA 335 P12)	Left de superheater	Circumferential weld	Base metal	Not appeared		Remaining in ferrite grain			Normal structure	Appeared	
			Fine grain HAZ			Disappeared				Not appeared	Coexist
			Coarse grain HAZ			Remaining					Coexist
			Weld metal			Remaining					
	Right de superheater	Circumferential weld	Base metal	Not appeared		Remaining in ferrite grain			Normal structure	Not appeared	
			Fine grain HAZ			Remaining				Not appeared	Coexist
			Coarse grain HAZ			Remaining					Coexist
			Weld metal			Disappeared					
Reheater outlet header (SA 335 P22)	Left	Circumferential weld	Base metal	Not appeared	Remained		No decrease in ferrite grain	Remaining			
			Fine grain HAZ				Remaining				
			Coarse grain HAZ			Remaining					
			Weld metal			Remaining					
	Right	Circumferential weld	Base metal	Appeared	Disappeared		No decrease in ferrite grain	Partially disappeared			
			Fine grain HAZ				Disappeared				
			Coarse grain HAZ			Disappeared					
			Weld metal			Disappeared					
Main steam pipe (SA 335 P22)	Left	Circumferential weld (near the stop valve) extrados side	Base metal	Appeared	Disappeared		No decrease in ferrite grain	Partially disappeared			
			Fine grain HAZ				Remaining				
			Coarse grain HAZ			Remained					
			Weld metal			Remained					
		Circumferential weld (near the stop valve) intrados side	Base metal	Appeared	Disappeared		No decrease in ferrite grain	Partially disappeared			
			Fine grain HAZ				Disappeared				
			Coarse grain HAZ			Disappeared					
			Weld metal			Disappeared					
View nos. for each area				×2000 (2 views) , ×10000 (4 views)							

Table Ⅰ-7 Quantitative evaluation of grain boundary precipitates

Component	Evaluated location	Material	Average diameter (μm)		Volume fraction	
			Base Metal	Fine grain HAZ	Base Metal	Fine grain HAZ
Platen-SH OutletHeader-Left	Base metal at left side	SA335P12	0.40	—	0.012	—
	Circumferential weld at left side	SA335P12	0.51	0.43	0.021	0.031
De-Suerheater-Left	Circumferential weld	SA335P12	0.85	0.33	0.018	0.020
De-Suerheater-Right	Circumferential weld	SA335P12	0.70	0.35	0.018	0.017
RH Outlet Header-Left	Circumferential weld at left side	SA335P22	0.43	0.38	0.019	0.025
RH Outlet Header-Right	Circumferential weld at right side	SA335P22	0.56	0.37	0.024	0.023
Main Steam Pipe-Left	Circumferential weld,extrados	SA335P22	0.53	0.38	0.022	0.022
Main Steam Pipe-Left	Circumferential weld,intrados	SA335P22	0.72	0.34	0.031	0.024



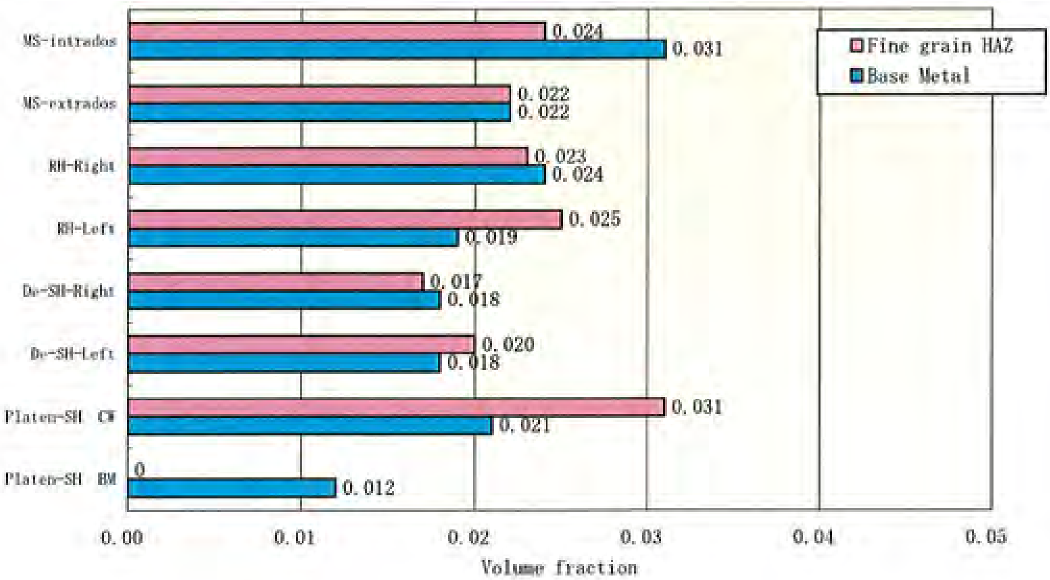


Table I -8 Precipitates free band width along grain boundary

Component	Evaluated location	Material	Precipitates free band width (μm) ※1
			Base Metal
RH Outlet Header-Left	Circumferential weld at left side	SA335P22	0.94
RH Outlet Header-Right	Circumferential weld at right side	SA335P22	1.10
Main Steam Pipe-Left	Circumferential weld,extrados	SA335P22	1.11
Main Steam Pipe-Left	Circumferential weld,intrados	SA335P22	0.94

※1 : Average value of 10 measured points

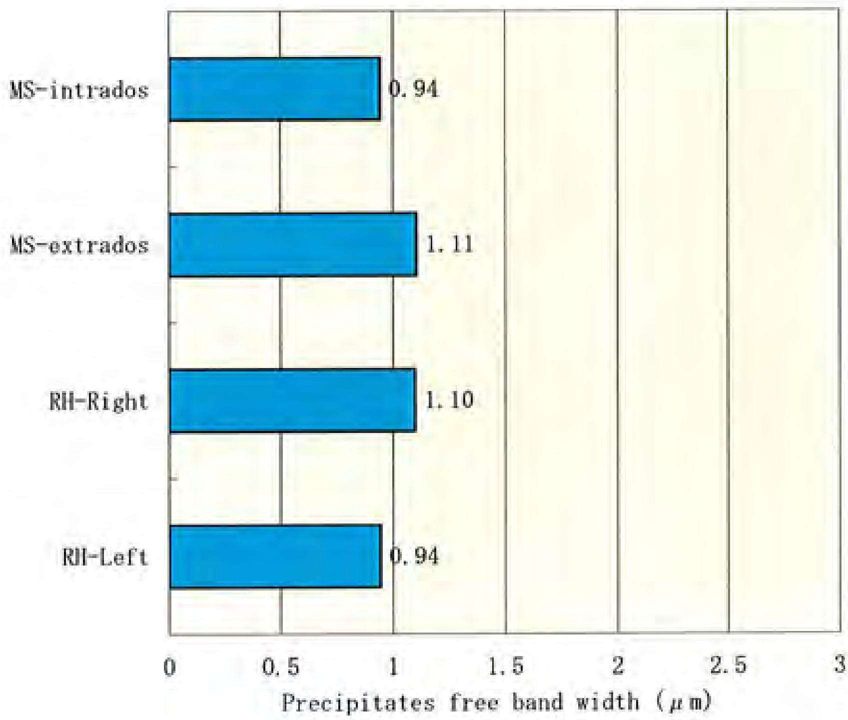


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Table I -9 Operational condition of evaluated components(Singrauli

Component	Location	Material		Designed					Hoop Stress	
				O.D.	t	Temperature	Pressure			
		ASME	JIS	(mm)	(mm)	(°C)	(MPa)	(kg/cm^2)	(MPa)	(kg/mm^2)
Platen SH Outlet Header-Left	circumferential weld at left side	SA335P12	STPA22	508.0	80.0	540	17.46	178.0	46.69	4.76
De-Suerheater-Left	Circumferential weld	SA335P12	STPA22	508.0	70.0	406	18.51	188.7	57.89	5.90
De-Suerheater-Right	Circumferential weld	SA335P12	STPA22							
RH Outlet Header-Left	Circumferential weld at left side	SA335P22	STPA24	558.8	50.0	540	4.26	43.5	21.68	2.21
RH Outlet Header-Right	Circumferential weld at right side	SA335P22	STPA24							
Main Steam Pipe-Left	Circumferential weld, extrados side	SA335P22	STPA24	520.0	85.0	540	17.46	178.0	44.67	4.55
Main Steam Pipe-Left	Circumferential weld, intrados side	SA335P22	STPA24							

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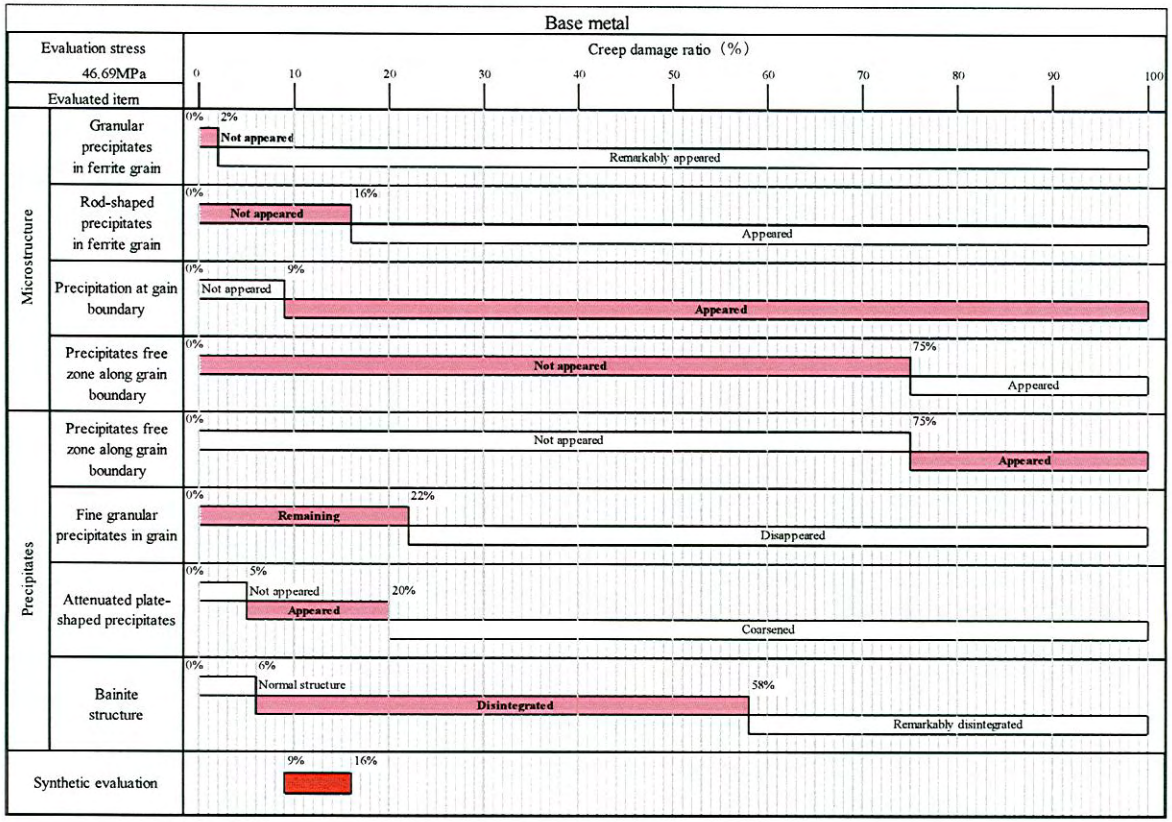

Evaluation Results I —1-1 Platen SH Outlet Header-Left Base metal at left side

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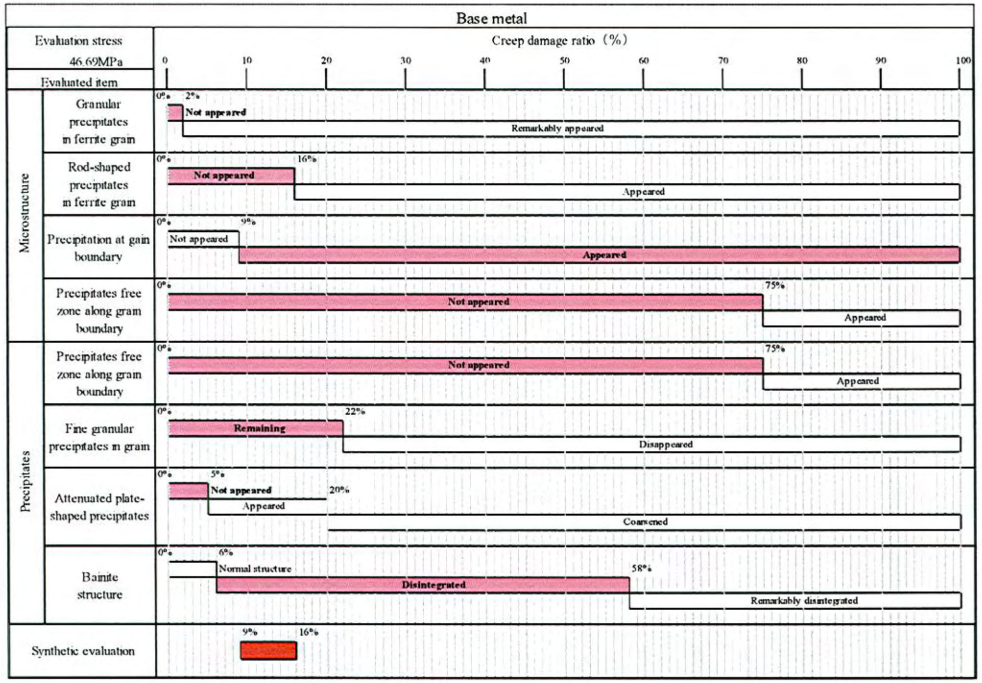
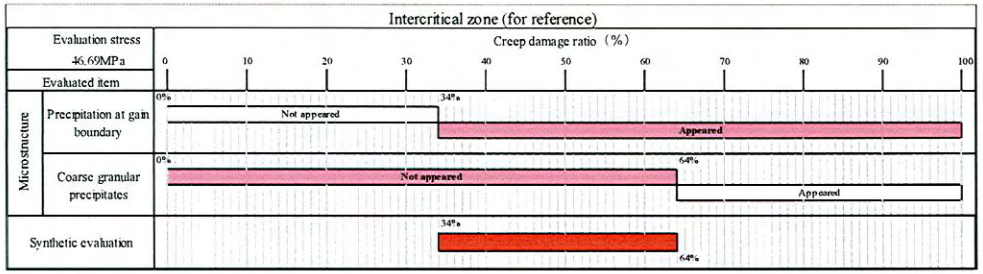
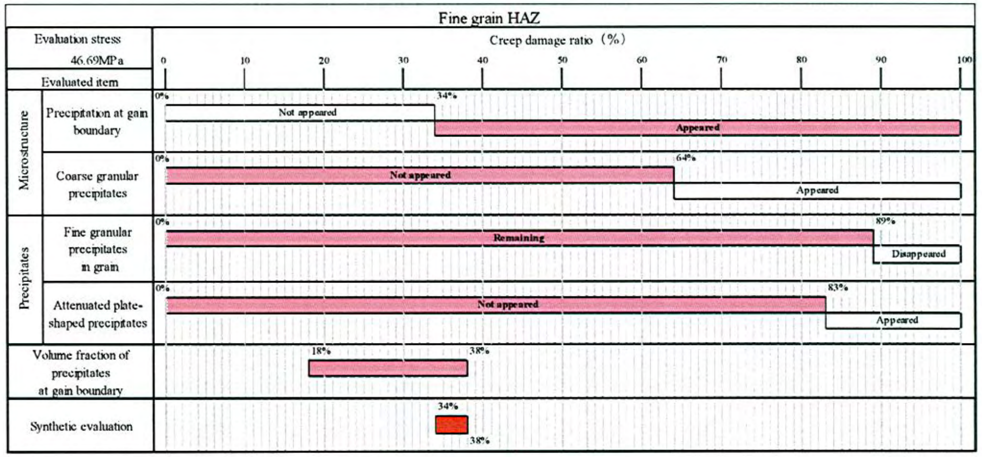
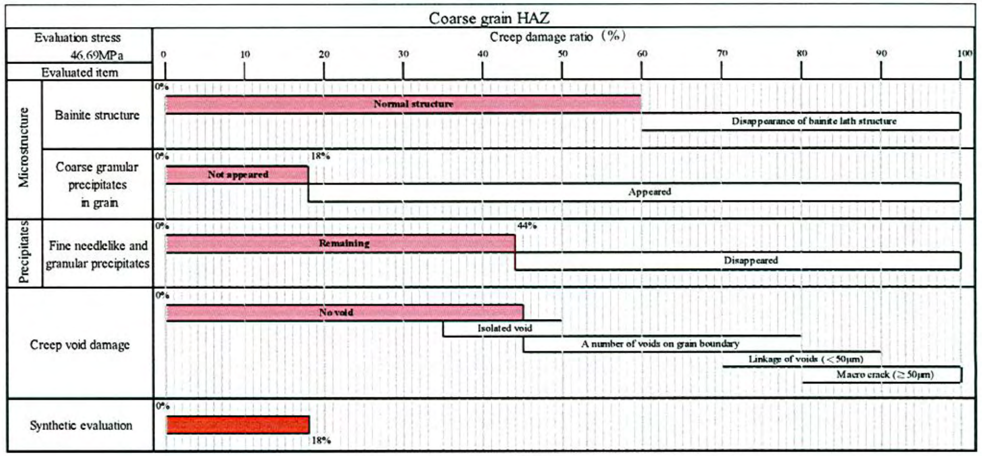
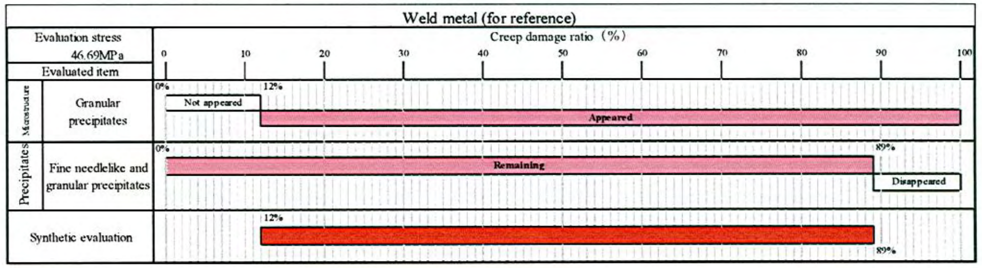




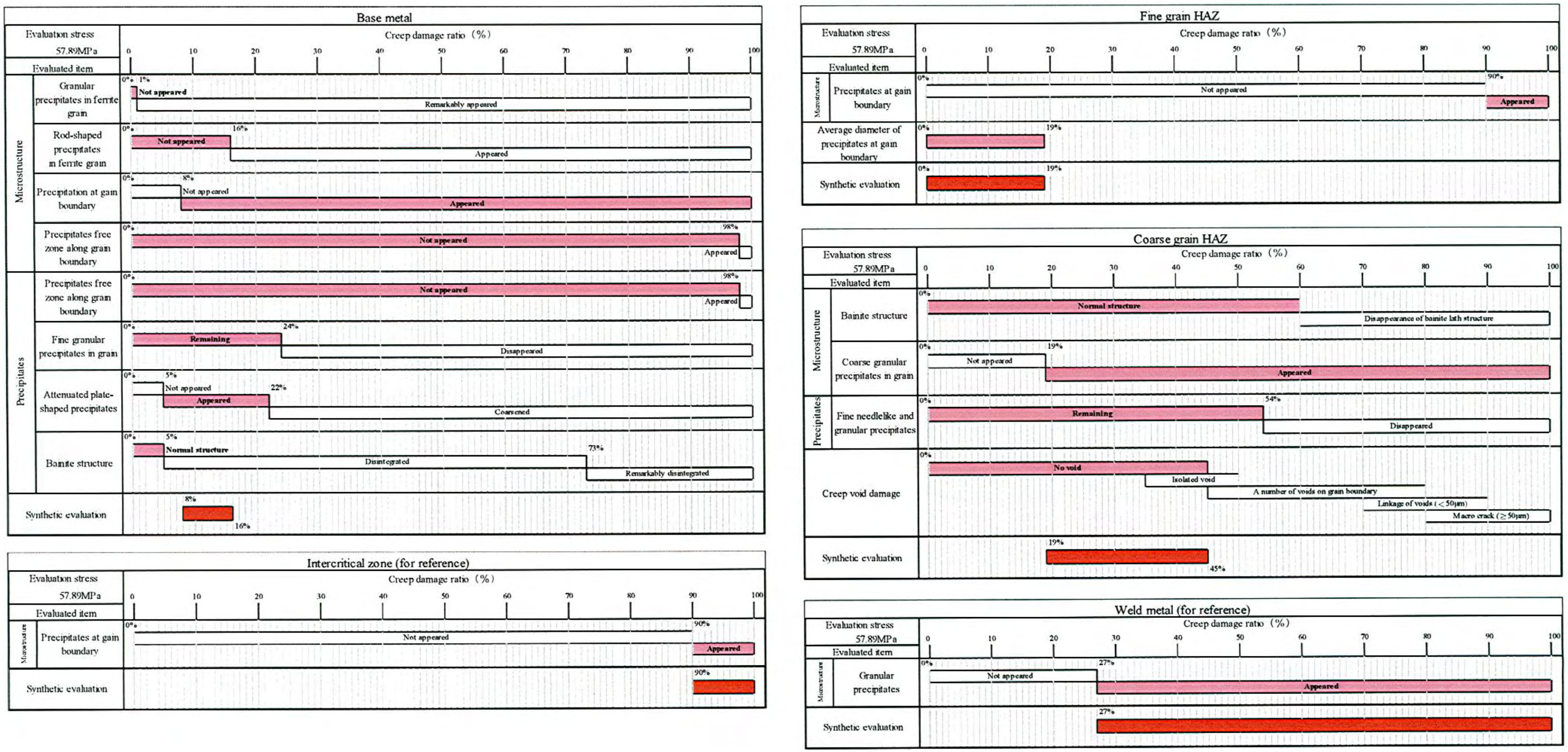




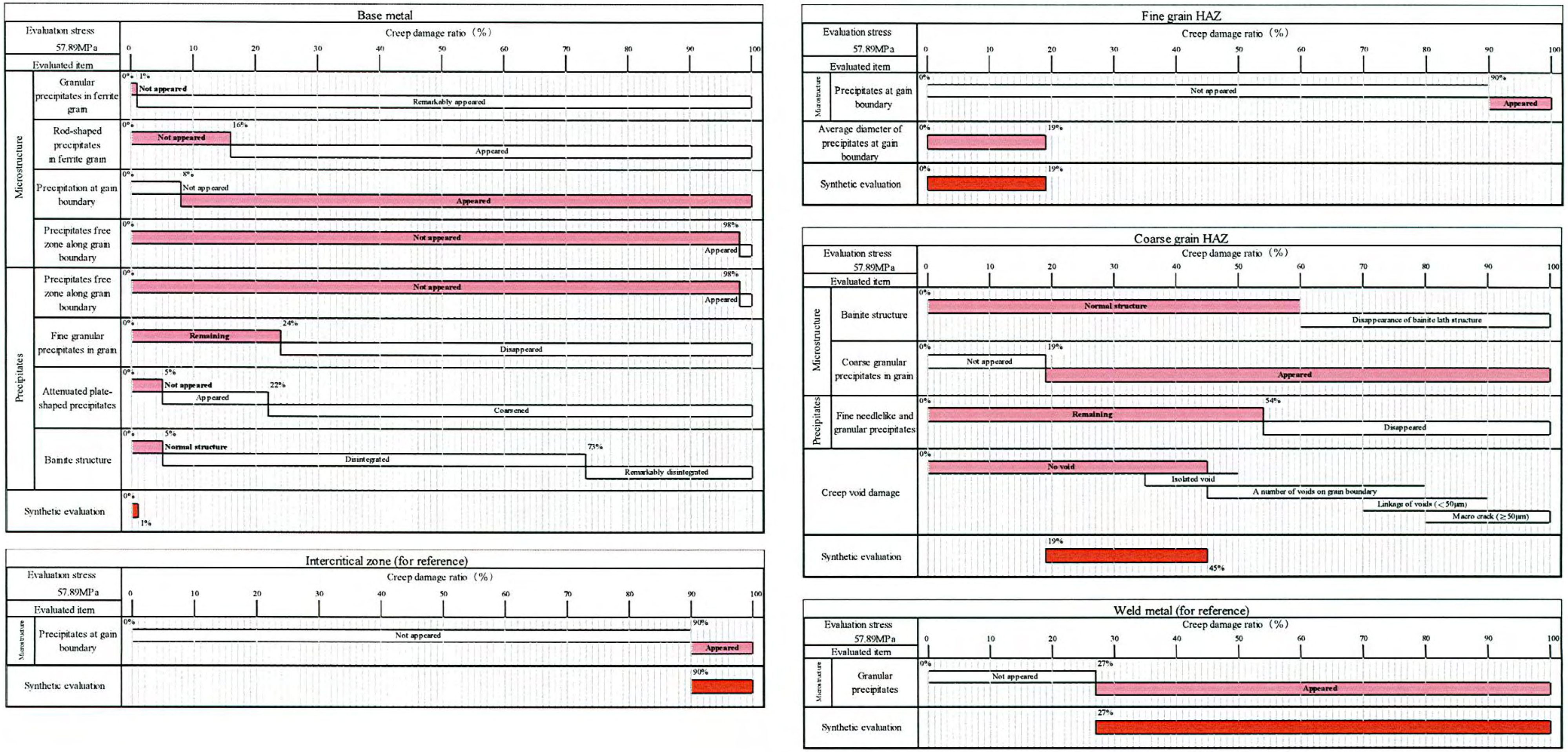


Evaluation Results I —1-2　Platen SH Outlet Header-Left circumferential weld at left side

06



Evaluation Results I −2 De-Suerheater-Left Circumferential weld



Evaluation Results I －3　De-Suerheater-Right　Circumferential weld

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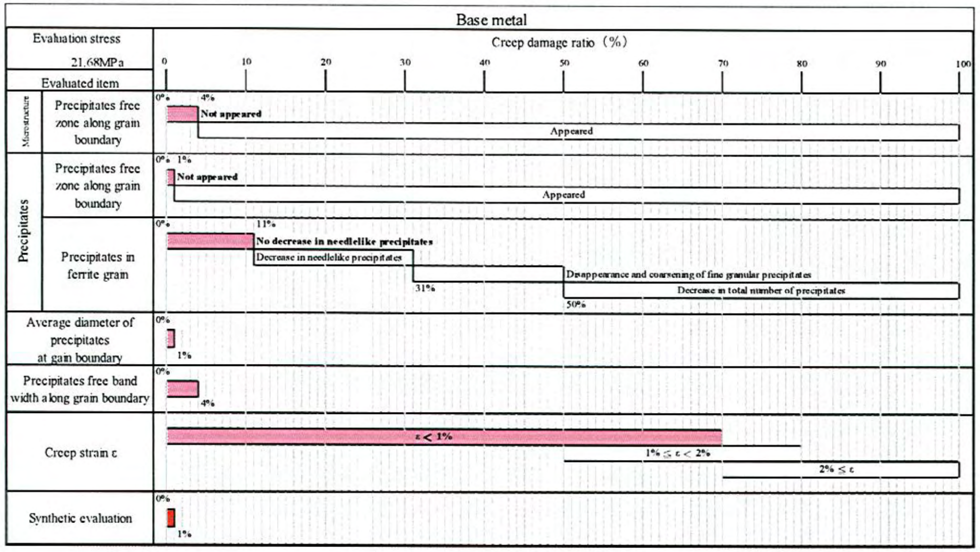

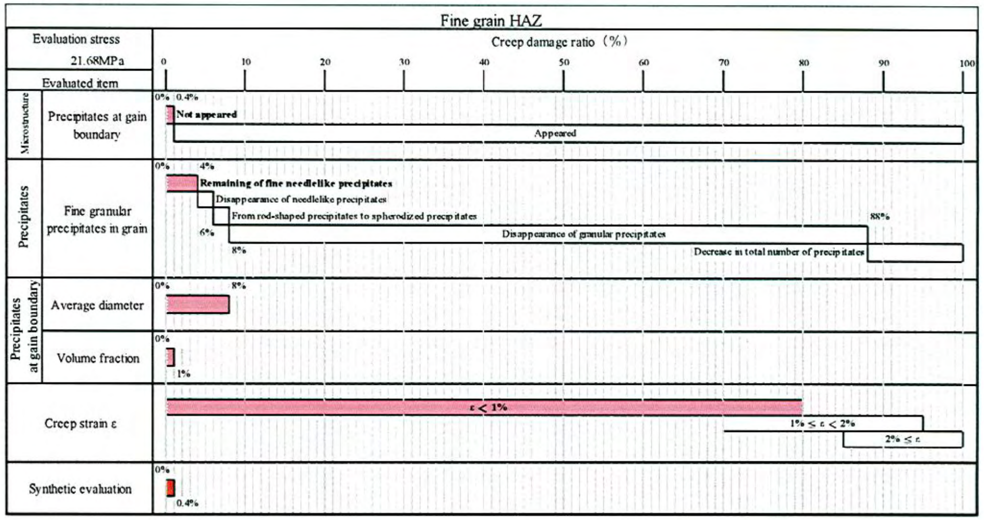

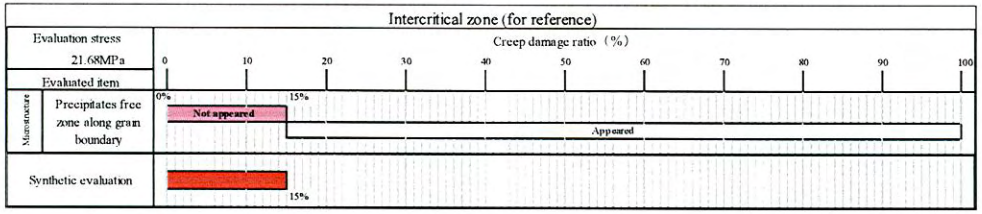

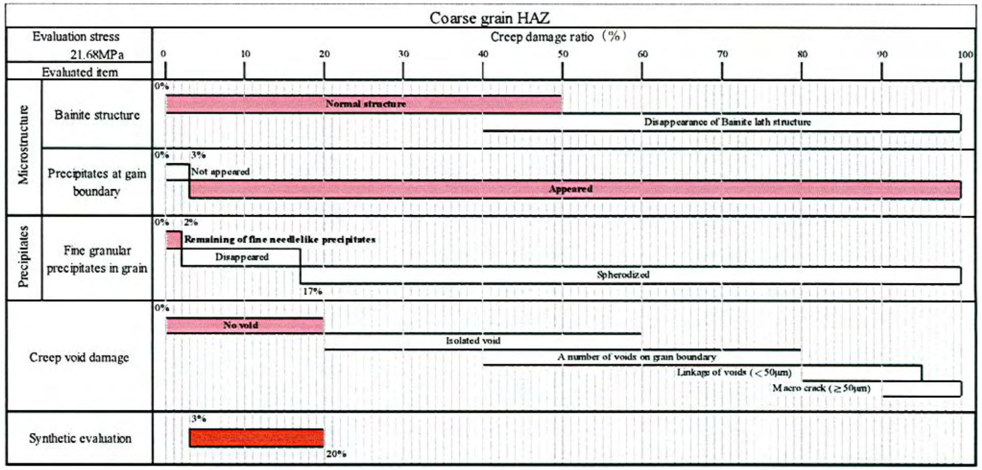

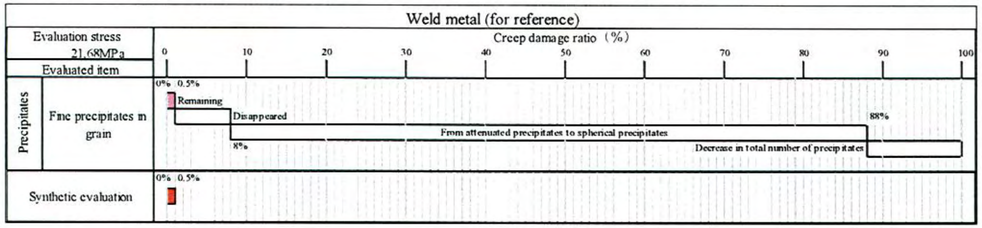

Evaluation Results I —4　RH Outlet Header-Left　Circumferential weld at left side

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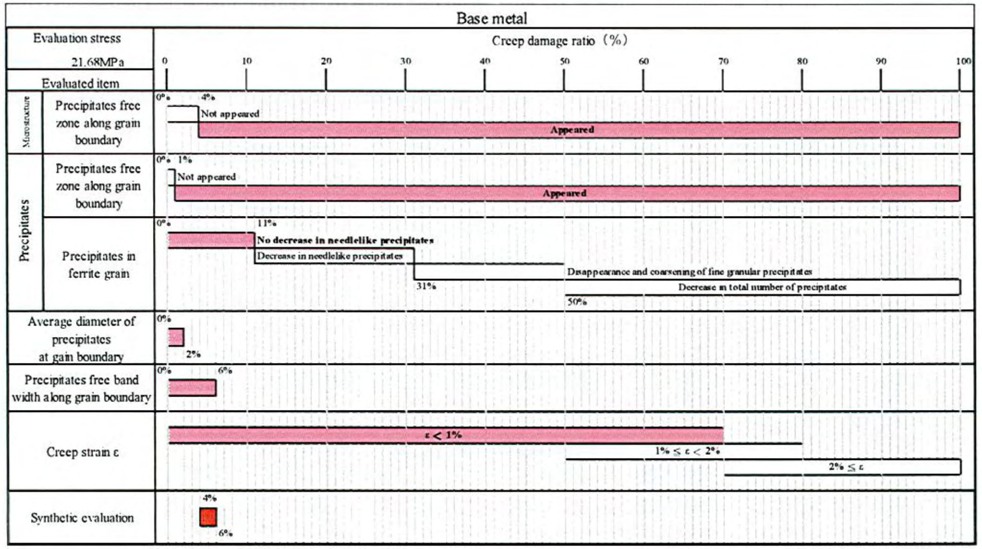

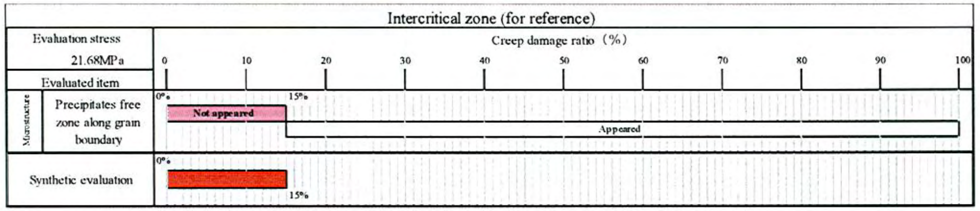

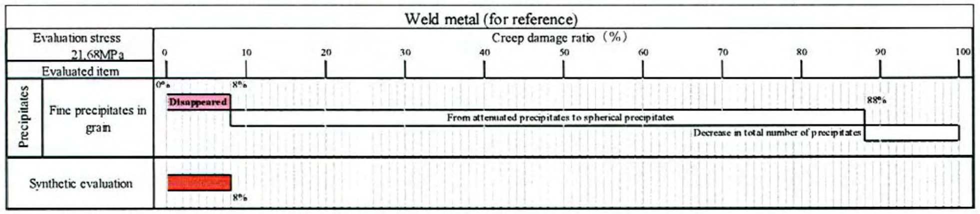

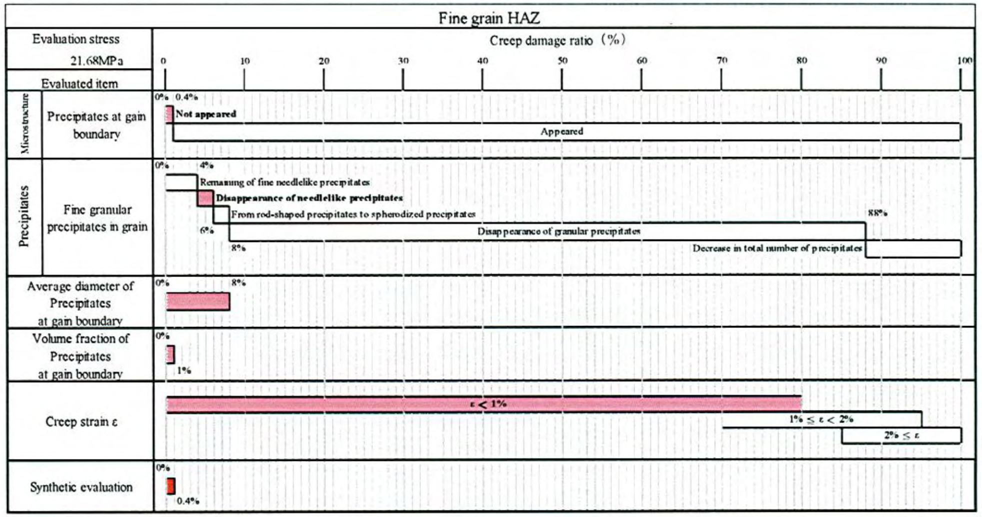

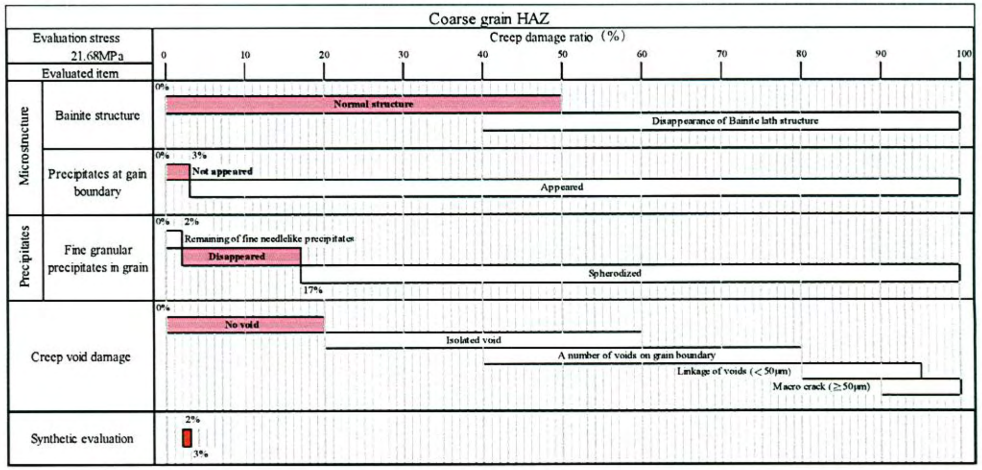

Evaluation Results I －5　RH Outlet Header-Right　Circumferential weld at right side