THIELSCH, INC.
195 FRANCES AVENUE
CRANSTON, RHODE ISLAND 02910

MARCH 2024

INSPECTION OF

HIGH-ENERGY PIPING SYSTEMS AND PRESSURE VESSELS

UNIT NO. 2

J.S. COOPER GENERATING STATION

EASTERN KENTUCKY POWER COOPERATIVE

SOMERSET, KENTUCKY

Peter Kennefick

Kyle Veon

April 12, 2024

Report No. 18577

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EXECUTIVE SUMMARY

In March of 2024, Thielsch, Inc. performed an inspection of the high-energy piping systems and pressure vessels in Unit No. 2 at the J.S. Cooper Generating Station of Eastern Kentucky Power Cooperative (EKPC) located in Somerset, Kentucky. This represents the second inspection of these piping systems and pressure vessels performed by Thielsch, Inc.

The table provided below identifies the components included in the scope of inspection. It also identifies the various examination techniques used. Finally, it provides the results of the examinations as well as any recommendations arising from the inspection.

Component	Examination Type	Results	Recommendations	Remaining Useful Life
Main Steam Piping System	VT, Dim, MT, UTT, UTPA, Rep, HD	Linear fatigue-type indication at hanger attachment weld No. MSH-5. (Removed at 1/8"); Acceptable. No pipe swelling or wall thinning. No subsurface indications. Operating in Class 1 creep mode.	Monitor indication during future inspections. Perform a similar inspection after three to five years of additional service (2027 to 2029).	Piping has consumed less than 20% of its useful life.
Hot Reheat Piping System	VT, Dim, MT, UTT, UTPA, Rep, HD	Transverse and linear fatigue-type indications at penetration No. P-3. (Removed with light grinding); Acceptable. No pipe swelling or wall thinning.	Monitor indications during future inspections. Perform a similar inspection after three to five years of additional service (2027 to 2029).	Piping has consumed less than 20% of its useful life.

Component	Examination Type	Results	Recommendations	Remaining Useful Life
Hot Reheat Piping System (Continued)		Inclusion type sub-surface indication detected at girth weld No. GW-7; Acceptable. Operating in Class 1 creep mode.		
Cold Reheat Piping System	VT, Dim, MT, UTT, UTPA	No evidence of significant service-related deterioration. No pipe swelling or wall thinning. No subsurface indications.	No immediate action required. Perform a similar inspection after five years of additional service (2029).	N/A
Boiler Feedwater Discharge Piping System	VT, Dim, MT, UTT, UTPA	Severe undercut at previous repair in crotch of penetration No. P-1; Acceptable. No pipe swelling. No subsurface indications. No wall loss associated with FAC.	Monitor undercut during future inspections. Perform a similar inspection after five years of additional service (2029).	20+ years
Condensate Line	VT, MT, UTT, UTPA	No evidence of significant service-related deterioration. No subsurface indications. No wall loss associated with FAC.	No immediate action required. Perform a similar inspection after five years of additional service (2029).	N/A
Deaerator Heater	VT, MT, UTT	Multiple broken tray box support welds, stitch welds, and attachments welds.	All noted conditions should be repaired.	N/A

Component	Examination Type	Results	Recommendations	Remaining Useful Life
Deaerator Heater (Continued)		Multiple small cracks in tray box by nozzles on the north and south sides. No significant wall thinning.	Perform a similar inspection after three years of additional service (2027).	
Deaerator Storage Tank	VT, MT, UTT	Linear fatigue-type indication at penetration No. P-4. (Removed with light grinding); Acceptable. No significant wall thinning.	Monitor surface indication during future inspections. Perform a similar inspection after three years of additional service (2027).	N/A

Examination Types	
VT - Visual Examination	MT - Magnetic Particle Examination
Dim - Diameter Measurements	UTT - Ultrasonic Wall Thickness Examination
Rep - Replication	UTPA - Ultrasonic Phased-Array Examination
HD - Hardness Determinations	

INTRODUCTION

In March of 2024, Thielsch, Inc. performed an inspection of the high-energy piping systems and pressure vessels in Unit No. 2 at the J.S. Cooper Generating Station of Eastern Kentucky Power Cooperative (EKPC) located in Somerset, Kentucky. This represents the second inspection of these piping systems and pressure vessels performed by Thielsch, Inc. The results of the previous inspection performed in September of 2019 are documented in Thielsch report No. 17012.

BACKGROUND INFORMATION

Unit No. 2 at the J.S. Cooper Generating Station was placed into commercial service in 1969. From 1969 to 2012 it was operated as a base-loaded unit and from 2012 to 2024 it has been operated as a cyclic-loaded unit.

The boiler in Unit No. 2 was designed and erected by Babcock & Wilcox. The design and erection of this boiler would have been performed in accordance with the requirements of Section I of the ASME Boiler and Pressure Vessel Code. (This section of the Code covers "Power Boilers".)

The high-energy piping systems in Unit No. 2 at the J.S. Cooper Generating Station were designed, fabricated, and erected in accordance with the requirements of the ANSI (now ASME) B31.1 Code on covering "Power Piping".

MARCH 2024 INSPECTION

Thielsch, Inc. performed an inspection of the high-energy piping systems and pressure vessels in March of 2024. A variety of nondestructive examination techniques were utilized to complete this inspection. These included detailed visual, wet fluorescent magnetic particle, and ultrasonic phased-array examinations as well as diameter and ultrasonic wall thickness measurements. A metallurgical evaluation was also performed in the form of in-situ metallographic examination (replication) and hardness determinations.

Where necessary, surface preparations were performed using superficial grinding prior to the inspection. This was performed in order to remove scale and debris which could mask indications. Where applicable, the nondestructive examinations were performed in accordance with procedures that conformed to the requirements of Section V of the ASME Boiler and Pressure Vessel Code. (This section of the Code covers "Nondestructive Examination".) Also where applicable, the nondestructive examinations were performed by personnel qualified to the requirements of ASNT SNT-TC-1A as Level II or Level III examiners.

Identification System

For identification purposes, each weld was assigned an identification number. The majority of the inspection locations were previously identified by plant personnel; however, a number of locations required new identification numbers. These locations are labeled on the isometric drawings for each piping system. For locating a particular position on the circumference of the piping, the following method was utilized in all instances:

1) Horizontal Pipe Sections - The top dead center was identified as the 12:00 o'clock position. Other positions were assigned clockwise while looking downstream.

2) Vertical Pipe Sections - The north side was identified as the 12:00 o'clock position. Other positions were assigned progressing clockwise while looking downstream.

Main Steam Piping System

The Main Steam piping system was reportedly fabricated using pipe manufactured in accordance with the requirements of ASTM Specification A-335, Grade P22. (For reference purposes, ASTM Specification A-335 covers "Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service". Grade P22 involves a 2-1/4 Cr - 1 Mo low-alloy steel material.)

Piping System	Dimensions			ASTM Material	Design	
	OD	NWT	Calc. MWT		Temp. (°F)	Pressure (psig)
Main Steam	8.625"	N/A	0.965"	A-335, Grade P22	1010	2,000
	12.000"	1.500"	1.342"			
	16.250"	2.000"	1.818"			

A sketch of the Main Steam piping system is provided in Fig. 1. Photographs of the inspection locations are provided in Figs. 2 through 6. All nondestructive examination reports for the Main Steam piping system are provided in Appendix A.

Visual Examination

The visual examination performed on the Main Steam piping system did not reveal gross misalignment, weld defects, indications of cracking, distortion, or other service-related deterioration at the inspection locations.

Diameter Measurements

Diameter measurements were recorded upstream and downstream of eight (8) girth welds on the Main Steam piping system. The diameter measurements would confirm whether the piping system had been fabricated using pipe of the specified outside diameter. These diameter measurements would also confirm whether the piping system had experienced dimensional changes, i.e., swelling, during the prior years of service.

The results of the diameter measurements recorded on the Main Steam piping system are summarized in the following table:

OD	ASTM A-335 Diameter Limits		Field Readings	
	Lower	Upper	Low	High
8.625"	8.594"	8.687"	8.813"	
12.000"	11.907"	12.093"	12.016"	12.078"
16.250"	16.088"	16.413"	16.328"	16.422"

Several of the diameter measurements recorded on the Main Steam pipe spools fell slightly beyond the permissible diameter limits. There was no metallurgical evidence in the replicas of general swelling such as would be produced by creep deterioration.

Magnetic Particle Examination

A wet fluorescent magnetic particle examination was performed at eight (8) girth welds, four (4) RT plugs, eighteen (18) penetrations, one (1) set of hanger lugs, and one (1) hanger attachment on the Main Steam piping system. This examination was performed to identify any surface defects such as fissuring or cracking. The wet fluorescent magnetic particle examination revealed the following surface indication:

- Hanger attachment No. MSH-5 - 4" linear indication in toe of weld. Removed at 1/8"; Acceptable.

Photographs of the indication location are provided in Fig. 7. This area should be monitored during future inspections.

Ultrasonic Wall Thickness Measurements

Ultrasonic wall thickness measurements were recorded at eight (8) girth welds on the Main Steam piping system. The ultrasonic wall thickness measurements were recorded on the upstream and downstream sides of each girth weld at four locations around the pipe circumference.

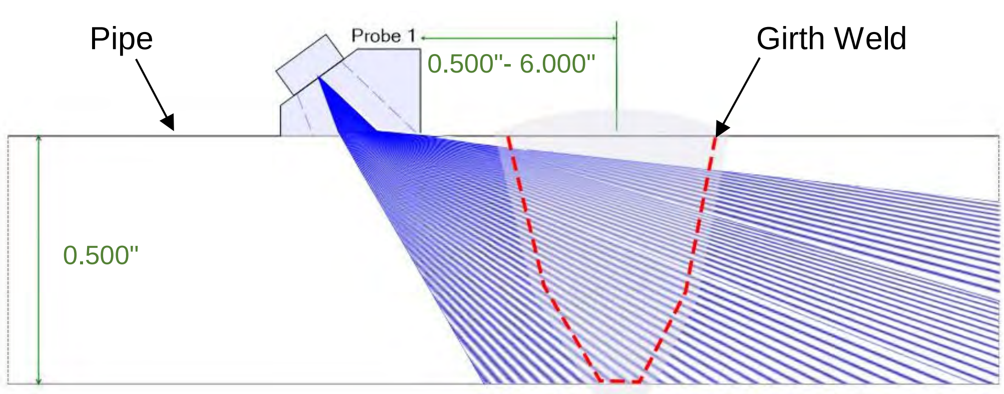
The results of the ultrasonic wall thickness measurements are summarized in the following table:

OD	Minimum Required Wall Thickness		Field Readings	
	Nominal	Calculated	Low	High
8.625"	N/A	0.965"	1.090"	1.205"
12.000"	1.500"	1.342"	1.661"	1.738"
16.250"	2.000"	1.818"	2.045"	2.344"

The wall thickness values were consistent with the specified nominal wall thickness and well above the calculated minimum wall thickness. This confirms that the applicable portions of the Main Steam piping system had not experienced significant reductions in wall thickness during the prior years of service.

Ultrasonic Phased-Array Examination

A detailed ultrasonic phased-array examination was performed at eight (8) girth welds included in the scope of inspection for the Main Steam piping system. The image depicted below represents the standard scanning plan for the girth welds. This examination was performed to identify any subsurface defects that might be present in the welds.



Girth Weld

The ultrasonic phased-array examination did not reveal any recordable subsurface indications through the cross-sectional volume of the girth welds.

Metallurgical Evaluation - Replication and Hardness Determinations

A metallurgical evaluation of the Main Steam piping system was performed utilizing in-situ metallographic examination or replication. This evaluation was performed to identify any microstructural changes that may have occurred in the Main Steam piping system as a result of the prior years of high-temperature service. Eight (8) replica foils were removed from the Main Steam piping system.

The following table identifies the locations from which the replica foils were removed and hardness determinations were performed. This table also identifies the microstructural condition of each replica foil with respect to the EPRI creep classification along with the corresponding hardness range. Finally, this table identifies the figures in which photomicrographs of a particular replica foil are provided.

Replica No.	Location	Material	Creep Class	Micro-structure	Hardness Range (BHN)	Fig.
MS-R1	Girth weld No. GW-1 at the 1:00 o'clock position, downstream of weld	2-1/4 - 1 Mo	1	Bainite and ferrite	139 - 168	8
MS-R2	Girth weld No. GW-2 at the 12:30 o'clock position, downstream of weld	2-1/4 - 1 Mo	1	Bainite and ferrite	147 - 175	9
MS-R3	Girth weld No. GW-3 at the 2:30 o'clock position, upstream of weld	2-1/4 - 1 Mo	1	Bainite and ferrite	149 - 160	10
MS-R4	Girth weld No. GW-4 at the 3:00 o'clock position, upstream of weld	2-1/4 - 1 Mo	1	Bainite and ferrite	152 - 197	11
MS-R5	Girth weld No. GW-5 at the 11:00 o'clock position, downstream of weld	2-1/4 - 1 Mo	1	Bainite and ferrite	159 - 183	12
MS-R6	Girth weld No. GW-6 at the 11:00 o'clock position, upstream of weld	2-1/4 - 1 Mo	1	Bainite and ferrite	143 - 196	13
MS-R7	Girth weld No. GW-7 at the 9:00 o'clock position, upstream of weld	2-1/4 - 1 Mo	1	Bainite and ferrite	187 - 190	14
MS-R8	Girth weld No. GW-8 at the 11:00 o'clock position, upstream of weld	2-1/4 - 1 Mo	1	Bainite and ferrite	142 - 160	15

The replica foils removed from the Main Steam piping system exhibited similar microstructures. Specifically, the microstructure exhibited by the welds consisted of acicular bainite or bainite with limited amounts of free ferrite. The microstructure exhibited by the heat-affected zones consisted of tempered bainite spheroidized carbide and ferrite. The microstructure exhibited by the base material also consisted of ferrite, carbide and tempered bainite, but with a slightly different grain size. The microstructures observed in all of the replica foils are typical for low-alloy steel pipe produced in accordance with ASTM Specification A-335, Grade P22 or fittings and filler material of the equivalent chemical composition. There was no evidence of microstructural anomalies relating to the original manufacture of the pipe or fittings, or the subsequent fabrication of the Main Steam piping system.

Bainite decomposition, along with carbide precipitation and agglomeration, are the early precursors to creep deterioration. Despite this, none of the replica foils removed from the Main Steam piping system exhibited evidence of creep deterioration. Specifically, these replica foils were free of void formation, void linkage, and microfissuring.

The hardness values recorded on the 2-1/4 Cr - 1 Mo piping correlate to tensile strength values greater than the 60,000 psi required for this material. There was nothing about the results of the hardness determinations that would call into doubt the integrity of the Main Steam piping system.

Hot Reheat Piping System

The Hot Reheat piping system was fabricated using a low-alloy steel pipe produced in accordance with ASTM Specification A-335, Grade P22.

Piping System	Dimensions			ASTM Material	Design	
	OD	NWT	Calc. MWT		Temp. (°F)	Pressure (psig)
Hot Reheat	18.000"	0.938"	0.652"	A-335, Grade P22	1010	575
	24.000	1.219"	0.869"			

A sketch of the Hot Reheat piping system is provided in Fig. 16. Photographs of the inspection locations are provided in Figs. 17 through 21. All nondestructive examination reports for the Hot Reheat piping system are provided in Appendix B.

Visual Examination

The visual examination performed on the Hot Reheat piping system did not reveal gross misalignment, weld defects, indications of cracking, distortion, or other service-related deterioration at the inspection locations.

Diameter Measurements

Diameter measurements were recorded upstream and downstream of seven (7) girth welds on the Hot Reheat piping system. The results of the diameter measurements are summarized in the following table:

OD	ASTM A-335 Diameter Limits		Field Readings	
	Lower	Upper	Low	High
18.000"	17.820"	18.180"	18.063"	18.719"
24.000"	23.760"	24.240"	24.078"	24.203"

Two of the diameter measurements recorded on the Hot Reheat pipe spools fell slightly beyond the permissible diameter limits. There was no metallurgical evidence in the replicas of general swelling such as would be produced by creep deterioration. As such, the results of the diameter measurements confirm that this portion of the Hot Reheat piping system was fabricated using the appropriate specified outside diameter.

Magnetic Particle Examination

A wet fluorescent magnetic particle examination was performed at seven (7) girth welds, five (5) RT plugs, five (5) penetrations, and one (1) set of hanger lugs on the Hot Reheat piping system. The wet fluorescent magnetic particle examination revealed the following surface indication:

- Penetration No. P-3 - 1/2" transverse indication in the weld and two 3" linear indications in toe of weld. Removed with light grinding; Acceptable.

Photographs of the indication locations are provided in Fig. 22. This area should be monitored during future inspections.

Ultrasonic Wall Thickness Measurements

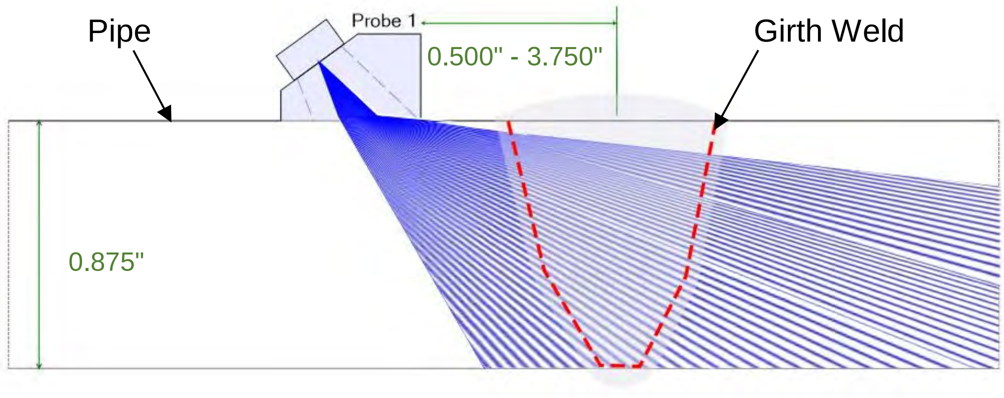
Ultrasonic wall thickness measurements were recorded at seven (7) girth welds on the Hot Reheat piping system. The results of the ultrasonic wall thickness measurements are summarized in the following table:

OD	Minimum Required Wall Thickness		Field Readings	
	Nominal	Calculated	Low	High
18.000"	0.938"	0.652"	0.878"	1.608"
24.000"	1.219"	0.869"	1.185"	1.655"

The wall thickness values were well above the calculated minimum wall thickness. This confirms that the applicable portions of the Hot Reheat piping system had not experienced significant reductions in wall thickness during the prior years of service.

Ultrasonic Phased-Array Examination

A detailed ultrasonic phased-array examination was performed at seven (7) girth welds included in the scope of inspection for the Hot Reheat piping system. The images depicted below represent the standard scanning plan for the welds. This examination was performed to identify any subsurface defects that might be present in the welds.



Girth Weld

The ultrasonic phased-array examination revealed the following recordable subsurface indications:

- Girth weld No. GW-7 - An inclusion type indication found transverse at the 11:30 position on the downstream side of the weld. Approximately 1.125" at depth with a through wall height of 0.125". Appears to be an original defect from manufacturing; Acceptable. This area should be monitored during future inspections.

Metallurgical Evaluation - Replication and Hardness Determinations

A metallurgical evaluation of the Hot Reheat piping system was performed utilizing in-situ metallographic examination or replication. Seven (7) replica foils were removed from the Hot Reheat piping system.

The following table identifies the locations from which the replica foils were removed and hardness determinations were performed. This table also identifies the microstructural condition of each replica foil with respect to the EPRI creep classification along with the corresponding hardness range. Finally, this table identifies the figures in which photomicrographs of a particular replica foil are provided.

Replica No.	Location	Material	Creep Class	Micro-structure	Hardness Range (BHN)	Fig.
HRH-R1	Girth weld No. GW-1 at the 11:00 o'clock position, downstream of weld	2-1/2 Cr - 1 Mo	1	Bainite and ferrite	177 - 189	23
HRH-R2	Girth weld No. GW-2 at the 2:00 o'clock position, downstream of weld	2-1/2 Cr - 1 Mo	1	Bainite and ferrite	183 - 195	24
HRH-R3	Girth weld No. GW-3 at the 9:30 o'clock position, downstream of weld	2-1/2 Cr - 1 Mo	1	Bainite and ferrite	176 - 208	25
HRH-R4	Girth weld No. GW-4 at the 2:30 o'clock position, upstream of weld	2-1/2 Cr - 1 Mo	1	Bainite and ferrite	175 - 178	26
HRH-R5	Girth weld No. GW-5 at the 9:30 o'clock position, upstream of weld	2-1/2 Cr - 1 Mo	1	Bainite and ferrite	177 - 188	27
HRH-R6	Girth weld No. GW-6 at the 10:30 o'clock position, downstream of weld	2-1/2 Cr - 1 Mo	1	Bainite and ferrite	182 - 209	28
HRH-R7	Girth weld No. GW-7 at the 2:00 o'clock position, upstream of weld	2-1/2 Cr - 1 Mo	1	Bainite and ferrite	164 - 193	29

The replica foils removed from the Hot Reheat piping system all exhibited similar microstructures. Specifically, the microstructure exhibited by the welds consisted of bainite with limited amounts of free ferrite. The microstructure exhibited by the heat-affected zones consisted of tempered bainite spheroidized carbide and ferrite. The microstructure exhibited by the base material also consisted of ferrite, carbide and tempered bainite, but with a slightly different grain size. These microstructures were typical for 2-1/4 Cr - 1 Mo low-alloy steel pipe produced in accordance with the requirements of ASTM A 335 Grade P22 or fittings and filler material of the equivalent chemical composition that have been in service at elevated temperatures for over extended period since 1969. There was no evidence of microstructural anomalies relating to the original manufacture of the pipe or fittings, or the subsequent fabrication of the Hot Reheat piping system.

The base material had experienced some microstructural transformations during the previous years of high-temperature service. This included partial decomposition of the bainite. It also included carbide precipitation and agglomeration at the ground boundaries. Despite the observed microstructural transformations, the replica foils were free of creep deterioration. Specifically, these replica foils were free of void formation, void linkage, and microfissuring.

The hardness values recorded on the 2-1/4 Cr - 1 Mo piping correlate to tensile strength values greater than the 60,000 psi required for this material. There was nothing about the results of the hardness determinations that would call into doubt the integrity of the Hot Reheat piping system.

Cold Reheat Piping System

The Cold Reheat piping system was fabricated using a carbon steel pipe produced in accordance with ASTM Specification A-106, Grade B. (For reference purposes, ASTM Specification A-106 covers "Seamless Carbon Steel Pipe for High-Temperature Service". Grade B involves a carbon steel material.)

Piping System	Dimensions			ASTM Material	Design	
	OD	NWT	Calculated MWT		Temp. (°F)	Pressure (psig)
Cold Reheat	18.000"	0.500"	0.333"	A-106, Grade B	670	620
	24.000"	0.688"	0.444"			

A sketch of the Cold Reheat piping system is provided in Fig. 30. Photographs of the inspection locations are provided in Figs. 31 through 34. All nondestructive examination reports for the Cold Reheat piping system are provided in Appendix C.

Visual Examination

The visual examination performed on the Cold Reheat piping system did not reveal gross misalignment, weld defects, indications of cracking, distortion, or other service-related deterioration at the inspection locations.

Diameter Measurements

Diameter measurements were recorded upstream and downstream of seven (7) girth welds on the Cold Reheat piping system. The results of the diameter measurements recorded on the Cold Reheat piping system are summarized in the following table:

OD	ASTM A-106 Diameter Limits		Field Readings	
	Lower	Upper	Low	High
18.000"	17.969"	18.093"	18.063"	18.375"
24.000"	23.969"	24.125"	23.984"	24.109"

All of the diameter measurements recorded on the Cold Reheat piping system fell within the permissible diameter limits. (Fittings do not have to conform to the same dimensional tolerances as pipe.)

Magnetic Particle Examination

A wet fluorescent magnetic particle examination was performed at seven (7) girth welds, one (1) RT plug, seam welds, nine (9) penetrations, and one (1) set of hanger lugs on the Cold Reheat piping system. The wet fluorescent magnetic particle examination did not reveal any recordable surface indications at or adjacent to the weldments.

Ultrasonic Wall Thickness Measurements

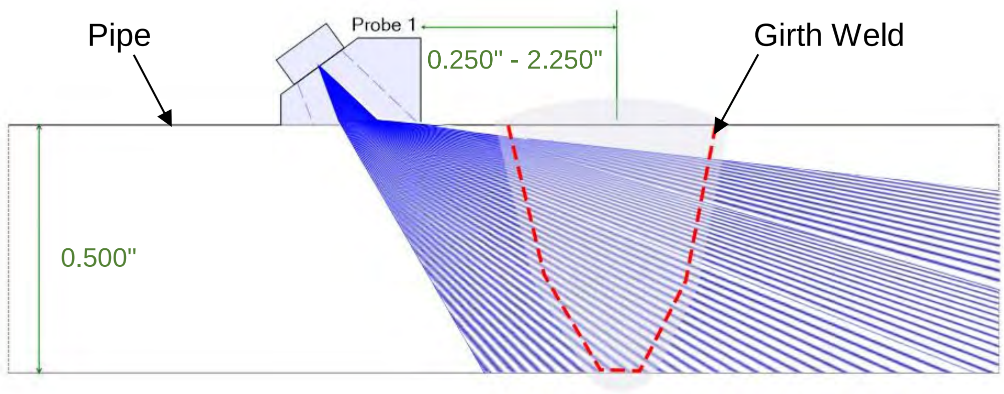
Ultrasonic wall thickness measurements were recorded at seven (7) girth welds included in the scope of inspection for the Cold Reheat piping system. The results of the ultrasonic wall thickness measurements are summarized in the following table:

OD	Minimum Required Wall Thickness		Field Readings	
	Nominal	Calculated	Low	High
18.000"	0.500"	0.333"	0.478"	0.844"
24.000"	0.688"	0.444"	0.685"	0.748"

The wall thickness values were well above the calculated minimum wall thickness. This confirms that the applicable portions of the Cold Reheat piping system had not experienced significant reductions in wall thickness during the prior years of service.

Ultrasonic Phased-Array Examination

A detailed ultrasonic phased-array examination was performed at seven (7) girth welds included in the scope of inspection for the Cold Reheat piping system. The images depicted below represent the standard scanning plan for the welds. This examination was performed to identify any subsurface defects that might be present in the welds.



Girth Weld

The ultrasonic phased-array examination did not reveal any recordable subsurface indications through the cross-sectional volume of the girth welds.

Boiler Feedwater Discharge Piping System

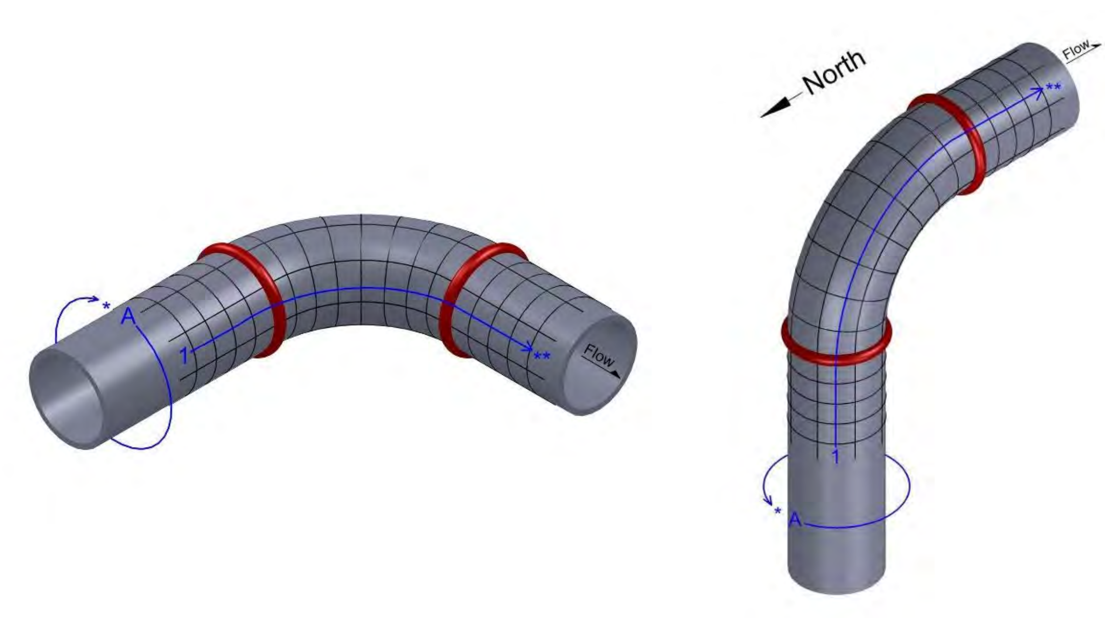
The Boiler Feedwater Discharge piping system was fabricated using a carbon steel pipe produced in accordance with ASTM Specification A-106, Grades B and C.

The available dimensions (nominal pipe size, outside diameter, and nominal wall thickness), material specifications, and design conditions for the Boiler Feedwater Discharge piping system are provided in the following table.

Piping System	Dimensions				ASTM Material	Design	
	NPS	OD	NWT	Calc. MWT		Temp. (°F)	Pressure (psig)
Boiler Feedwater Discharge	N/A	12.750"	*1.125"	0.980"	A-106, Grade B	650	2800
	N/A	8.625"	*0.812"	0.663"			
	N/A	12.750"	*1.000"	0.853"	A-106, Grade C		
	N/A	8.625"	*0.750"	0.577"			

Assumed

The inspection of the Boiler Feedwater Discharge piping system consisted of a detailed visual examination to identify any obvious conditions of deterioration or distortion. This was followed by carefully transcribing a 2" x 2" grid pattern onto the entire elbow circumference and length at each location. The grid pattern incorporated letter designations, starting with "A" and continuing clockwise around the circumference of the pipe while looking in the direction of flow. The number designation ran along the length of the pipe in the direction of flow. Ultrasonic wall thickness measurements were then recorded at each grid point. A visual aid is provided below:



A sketch of the Boiler Feedwater Discharge piping system is provided in Fig. 35. Photographs of inspection locations are provided in Figs. 36 and 37. All nondestructive examination reports are provided in Appendix D.

Visual Examination

The visual examination of the selected areas of the Boiler Feedwater Discharge piping system did not reveal gross misalignment, weld defects, indications of cracking, distortion, or other service-related deterioration at the inspection locations. The visual examination revealed severe undercut at previous repair in crotch of penetration No. P-1, Fig. 38. This condition is considered acceptable and the area should be monitored during future inspections.

Diameter Measurements

Diameter measurements were recorded upstream and downstream of two (2) girth welds on the Boiler Feedwater Discharge piping system. The results of the diameter measurements recorded on the Boiler Feedwater Discharge piping system are summarized in the following table:

OD	ASTM A-106 Diameter Limits		Field Readings	
	Lower	Upper	Low	High
8.625"	8.594"	8.687"	8.500"	8.594"
12.750"	12.719"	12.843"	12.734"	12.766"

The diameter measurements were compared to the limits for pipe set forth in ASTM Specification A-106.

One of the diameter measurements recorded on the Boiler Feedwater Discharge piping system fell slightly below the permissible diameter limits. As such, the results of the diameter measurements confirm that this portion of the Boiler Feedwater Discharge piping system was fabricated using the appropriate specified outside diameter.

Magnetic Particle Examination

A wet fluorescent magnetic particle examination was performed at two (2) girth welds, two (2) saddle welds, and two (2) penetrations on the Boiler Feedwater Discharge piping system. The wet fluorescent magnetic particle examination did not reveal any recordable indications at or adjacent to the weldments.

Ultrasonic Wall Thickness Measurements

The results of the ultrasonic wall thickness measurements performed on the Boiler Feedwater Discharge piping system are summarized in the following table.

Location	OD	Minimum Required Wall Thickness		Field Readings				Short Term Corrosion Rate	Remaining Useful Life (Years)
				2019	2024				
		NWT	Calc.	Min.	Min.	Max.	Avg.		
Loc. 1	8.625"	*0.812"	0.663"	0.739"	0.739"	0.908"	0.822"	0.000"	20+
		*0.750"	0.577"					0.000"	20+
Loc. 2	12.750"	*1.125"	0.980"	1.095"	1.101"	1.197"	1.142"	0.000"	20+
		*1.000"	0.853"					0.000"	20+

*Assumed

The wall thickness readings were above the calculated minimum required wall thicknesses. No locations revealed evidence of significant localized or general wall loss that would be indicative of flow-assisted corrosion.

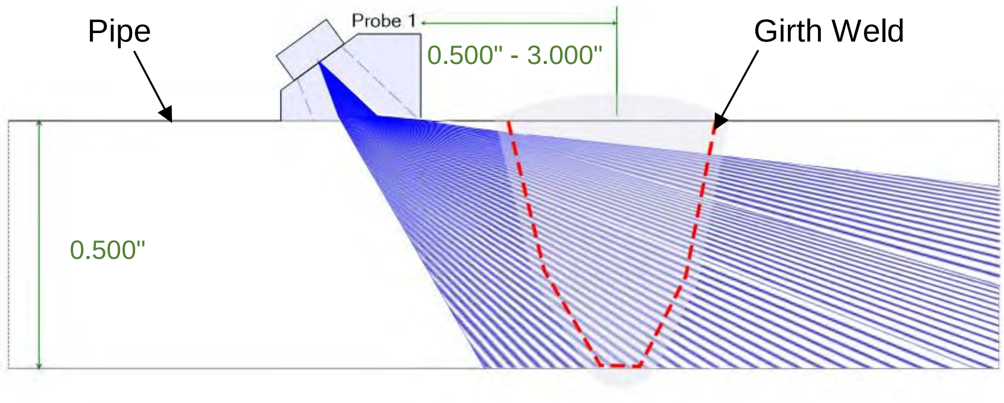
Ultrasonic wall thickness measurements were also recorded at two (2) girth welds on the Boiler Feedwater Discharge piping system. The results of the ultrasonic wall thickness measurements are summarized in the following table:

OD	Minimum Required Wall Thickness		Field Readings	
	Nominal	Calculated	Low	High
8.625"	*0.750"/*0.812"	0.663"/0.577"	0.783"	0.853"
12.750"	*1.000"/*1.125"	0.980"/0.853"	1.096"	1.143"

*Assumed

Ultrasonic Phased-Array Examination

A detailed ultrasonic phased-array examination was performed at two (2) girth welds included in the scope of inspection for the Boiler Feedwater Discharge piping system. The images depicted below represent the standard scanning plan for the welds. This examination was performed to identify any subsurface defects that might be present in the welds.



Girth Weld

The ultrasonic phased-array examination did not reveal any recordable subsurface indications through the cross-sectional volume of the welds.

Condensate Line

The Condensate Line was fabricated using a carbon steel pipe produced in accordance with ASTM Specification A-106, Grades B and C.

The available dimensions (nominal pipe size, outside diameter, and nominal wall thickness), material specifications, and design conditions were not available for the Condensate Line at the time of this inspection.

The inspection of the Condensate Line consisted of a detailed visual examination to identify any obvious conditions of deterioration or distortion. This was followed by carefully transcribing a 2" x 2" grid pattern onto the entire elbow circumference and length at each location. The grid pattern incorporated letter designations, starting with "A" and continuing clockwise around the circumference of the pipe while looking in the direction of flow. The number designation ran along the length of the pipe in the direction of flow. Ultrasonic wall thickness measurements were then recorded at each grid point.

A sketch of the Condensate Line is provided in Fig. 39. Photographs of inspection locations are provided in Fig. 40. All nondestructive examination reports are provided in Appendix E.

Visual Examination

The visual examination of the selected areas of the Condensate Line did not reveal gross misalignment, weld defects, indications of cracking, distortion, or other service-related deterioration at the inspection locations.

Magnetic Particle Examination

A wet fluorescent magnetic particle examination was performed at two (2) girth welds and two (2) penetrations on the Condensate Line. The wet fluorescent magnetic particle examination did not reveal any recordable surface indications at or adjacent to the weldments.

Ultrasonic Wall Thickness Measurements

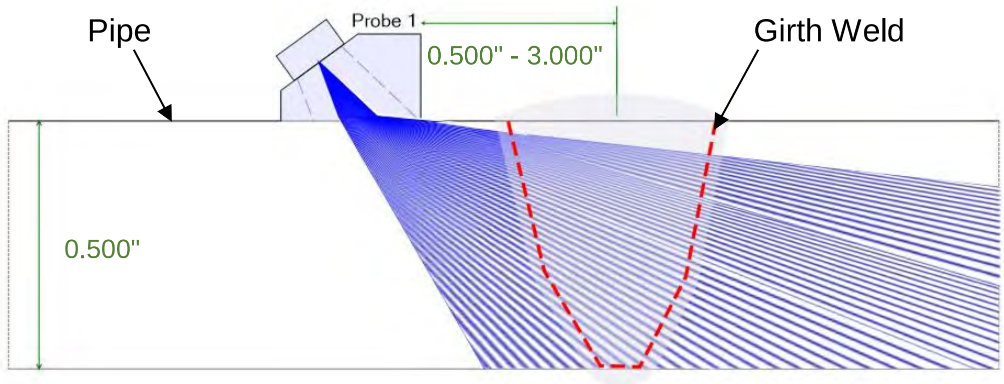
Ultrasonic wall thickness measurements were recorded at one elbow on the Condensate Line. The results of the ultrasonic wall thickness measurements are summarized in the following table:

Location	OD	Minimum Required Wall Thickness		Field Readings			
				2019	2024		
		NWT	Calc.	Min.	Min.	Max.	Avg.
Loc. 1 Elbow	N/A	N/A	N/A	0.319"	0.334"	0.461"	0.399"

No locations revealed evidence of significant localized or general wall loss that would be indicative of flow-assisted corrosion.

Ultrasonic Phased-Array Examination

A detailed ultrasonic phased-array examination was performed at two (2) girth welds included in the scope of inspection for the Condensate Line. The images depicted below represent the standard scanning plan for the welds. This examination was performed to identify any subsurface defects that might be present in the welds.



Girth Weld

The ultrasonic phased-array examination did not reveal any recordable subsurface indications through the cross-sectional volume of the welds.

Deaerator Heater and Storage Tank

The deaerator heater and storage tank were designed and fabricated by the Chicago Heater Company of Chicago, Illinois and fabricated by the J.J. Finnigan Company, Inc. The design and fabrication of these vessels would have been performed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. (This Section of the Code covers "Pressure Vessels".)

The deaerator heater was reportedly fabricated using carbon steel plate material produced in accordance with the requirements of ASME Specification SA-285, Grade C. (For reference purposes, ASME Specification SA-285 covers "Pressure Vessel

Plates, Carbon Steel, Low-and-Intermediate Tensile Strength". Grade C involves a carbon steel material.)

For ease of reference, the vessel specifications are summarized in tabular form below:

	Heater	**Storage Tank**
Designer:	Chicago Heater Company	
Fabricator:	J.J. Finnigan Company, Inc.	
National Board No.:	6219	6220
Overall Length:	21'-0"	45'-0"
Outside Diameter:	6'-6"	11'-6"
Shell Material:	SA-285, Grade C	SA-285, Grade C
Shell Thickness (Nominal):	0.3125"	0.6525"
Head Material:	SA-285, Grade C	SA-285, Grade C
Head Thickness (Nominal):	0.500"	0.750"
Design Pressure:	75 psig	75 psig
Design Temperature:	500°F	500°F

Copies of the Manufacturer's Data Reports, Form U-1A for the deaerator heater and storage tank were not available at the time of this inspection.

Deaerator Heater

The deaerator heater is a horizontal vessel located atop the storage tank. For identification purposes, the top of this vessel was identified as the 12:00 o'clock position. All other positions around the circumference were identified clockwise looking west.

A sketch depicting the inspection locations within the deaerator heater is provided in Fig. 41. Photographs of the interior inspection locations are provided in Figs. 42 through 44. This examination was performed with the trays removed. The nondestructive examination reports detailing the results of the inspection are provided in Appendix F.

Visual Examination

The visual examination of the deaerator heater vessel did not reveal any evidence of significant service-related deterioration. Specifically, there was no visible cracking, severe reductions in wall thickness (either general or localized), or other conditions expected to have a significant adverse effect on the integrity of this vessel. The visual examination did however reveal the following deficiencies:

- Multiple broken tray box support welds; Rejectable.
- All bottom stitch welds are broken on tray box at west end; Rejectable.
- Northwest end attachment from shell to tray box broken; Rejectable.
- All side wall welds to horizontal supports are broken on the south end inside tray box; Rejectable.
- Multiple small cracks in tray box by nozzles on the north and south sides; Rejectable.
- All, except west end, side wall welds to horizontal supports are broken on north end inside tray box; Rejectable.

Photographs of the typical deficiencies are provided in Figs. 45 through 51. It is recommended that all noted conditions be repaired.

Magnetic Particle Examination

A wet fluorescent magnetic particle examination was performed on all accessible welds within the deaerator heater in order to identify any indications of surface cracking or fissuring. The wet fluorescent magnetic particle examination did not reveal any recordable indications at or adjacent to the weldments.

Ultrasonic Wall Thickness Measurements

Ultrasonic wall thickness measurements were recorded at various locations within the deaerator heater. These measurements were compared to the applicable nominal wall thicknesses for this vessel.

The results of the ultrasonic thickness measurements are summarized in the following table:

Section	Minimum Required Wall Thickness		Field Readings	
	Nominal	Calculated	Low	High
Shell	0.3125"	0.185"	0.317"	0.341"
West Head	0.500"	0.184"	0.494"	0.532"

The wall thickness values were consistent with the nominal wall thicknesses and well above the calculated minimum required wall thicknesses. This confirms that the deaerator heater was fabricated using plate material supplied in accordance with the specified nominal wall thicknesses. Moreover, it confirms that the deaerator heater has not experienced significant reductions in wall thickness as a result of erosion, corrosion, etc.

Deaerator Storage Tank

A sketch depicting the inspection locations within the deaerator storage tank is provided in Fig. 52. Photographs of the interior inspection locations are provided in Figs. 53 through 60. The nondestructive examination reports detailing the results of the inspection are provided in Appendix G.

Visual Examination

The visual examination did not reveal any evidence of significant service-related deterioration. Specifically, there was no visible cracking, severe reductions in wall thickness (either general or localized), or other conditions expected to have a significant adverse effect on the integrity of this vessel.

Magnetic Particle Examination

A wet fluorescent magnetic particle examination was performed on all accessible welds within the deaerator storage tank in order to identify any indications of surface cracking or fissuring. The wet fluorescent magnetic particle examination revealed the following surface indication:

- Penetration No. P-4 - 1/2" linear indication in toe of weld. Removed with light grinding; Acceptable.

Photographs of the indication location are provided in Fig. 61. This area should be monitored during future inspections.

Ultrasonic Wall Thickness Measurements

Ultrasonic wall thickness measurements were recorded at selected locations within the deaerator storage tank in order to identify areas of potential wall loss. The results of the ultrasonic wall thickness measurements are summarized in the following table:

Section	Minimum Required Wall Thickness		Field Readings	
	Nominal	Calculated	Low	High
Shell	0.6525"	0.327"	0.502"	0.601"
Heads	0.750"	0.326"	0.761"	0.843"

Although multiple thickness values fell below the nominal wall thicknesses, all thickness readings were well above the calculated minimum required wall thicknesses. This confirms that the deaerator storage tank was fabricated using plate material supplied in accordance with the nominal wall thicknesses. Moreover, it confirms that the deaerator storage tank has not experienced significant reductions in wall thickness as a result of erosion, corrosion, etc.

DISCUSSION

Thielsch, Inc. performed a detailed inspection of the high-energy piping systems and pressure vessels in Unit No. 2 at the J.S. Cooper Generating Station of Eastern Kentucky Power Cooperative (EKPC). This inspection was intended to assess the condition of these components and to evaluate the effects of the prior years of high-temperature service. This inspection was also intended to identify any conditions requiring immediate corrective action, e.g., repair welding. The information generated by this inspection should also be used to establish reinspection intervals to ensure the continued reliability of these components.

General Comments on Damage in High-Energy Piping Systems

Damage in high-temperature piping systems is often the result of creep, fatigue, and microstructural changes. These processes may act independently, additively, or synergistically. While leaks occur from time to time in the girth welds of these systems, the major catastrophic failures have historically occurred in seam-welded piping.

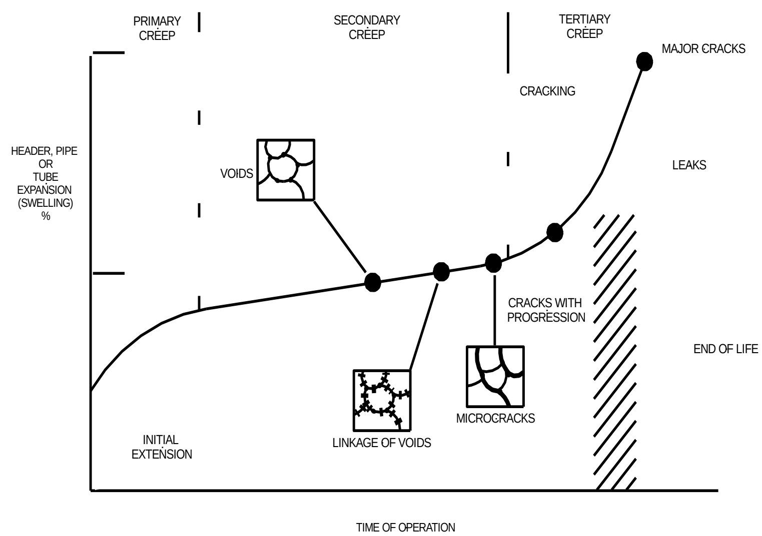
Damage in seam welds and girth welds can be oriented both circumferentially and transversely to the weld. Transverse cracking or creep damage is caused by the long-term application of pressure stress (i.e., hoop stress). Circumferential creep cracking, however, is primarily caused by bending at the operating temperature. System stresses will typically result in crack development at the site of the weakest weld microstructure. Damage of this form is often observed in the partially transformed region of the heat-affected zone where the welding thermal cycles are sufficient to coarsen the carbides present, thus leading to a narrow band of low-strength material. Fatigue damage is also influenced by geometric stress concentrations, such as the local weld geometry or backing bars.

Steel materials are normally subject to changes in microstructures when the steels are exposed to temperatures above 800°F to 1000°F. The changes in microstructure tend to relate to the maximum temperatures reached and the time spent at the respective temperatures.

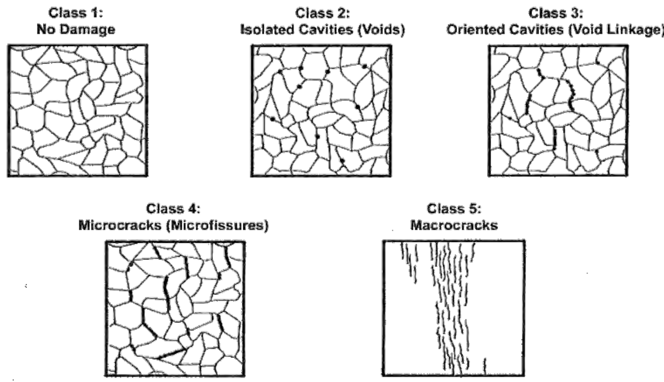
If the temperatures are sufficiently high and the stresses to which the header, steel pipe, welds, or tubing are subjected are of sufficient magnitude, dimensional changes may develop. Such dimensional changes at elevated temperatures are known as creep.

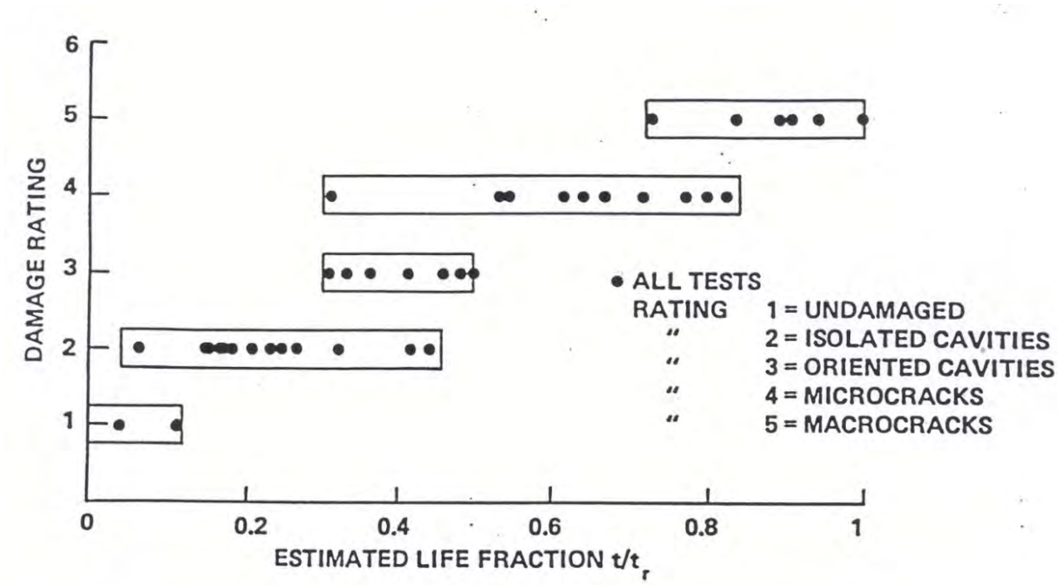
Creep represents the permanent plastic deformation which can occur at elevated temperatures and at stresses significantly less than the yield strength of the steel at the same elevated temperatures.

Creep at elevated temperatures is normally identified by a curve which shows four portions as illustrated below. (For reference purposes, Neubauer's creep classification developed by EPRI contains five different stages of creep ranging from Class 1 through Class 5, and the EPRI-accepted approach for correlating Neubauer's Damage Rating and Consumed Life Fraction are shown below)



EPRI CLASSIFICATION OF CREEP DAMAGE





The first portion involves the initial extension (or expansion) at elevated temperature. This extension is partially elastic.

In the next stage, the extension (or expansion) rate decreases with time. This stage is also called a transient or primary creep stage. The primary creep stage is not considered to represent damage.

Subsequently, a stage occurs on the creep curve located where the rate of creep (expansion) is nearly constant. This stage is also called secondary creep. The period of secondary creep, after some expansion (i.e., in the latter period of the stage), is evidenced by initial void formation along the grain boundaries. In time, these tend to join or "link up". Void formation generally tends to develop after approximately 50% of the life of the pipe material has been consumed.

The fourth stage of the creep curve, located beyond the constant creep rate portion, involves a rapidly increasing creep rate. This stage is called tertiary creep. Tertiary creep involves grain boundary fissuring (or microcracking). After this stage is reached, the material would tend to develop failure. This may represent a "remaining-life" period of 5% to 10% of the prior operating period. Thus, when the header or pipe material reaches the tertiary creep stage, the end of the useful life of the steel material, at the specific area of high stress levels, is being approached.

In many components, the tertiary creep stage may not be reached until after 200,000 to 500,000 hours of operation, or longer. However, in other instances, particularly involving overheating of Superheater tubes, the tertiary creep stage has been reached after only 10,000 to 50,000 hours of operation. Such overheating, however, would generally involve temperatures of 1100°F to 1200°F.

An article entitled "Proper Piping System Exams Keep Money in the Plant" is provided in Appendix H.

General Comments on Flow-Assisted Corrosion

In recent years, several catastrophic failures in the feedwater piping of utility steam power and nuclear power plants and pulp and paper facilities have been attributed to wall thinning of the piping enhanced by a phenomenon termed "Flow-Assisted Corrosion" (FAC). These catastrophic failures, some of which have resulted in loss of life, have brought to the attention of insurance underwriters, trade organizations and plant managers the need to implement wall thickness monitoring programs. A number of catastrophic failures caused by flow-assisted corrosion have been evaluated by Thielsch, Inc.

Thielsch, Inc. has developed and refined evaluation programs for over 20 years. These types of programs involve several phases. First, a review of the applicable systems is performed and, based upon experience and engineering evaluations, locations most susceptible to wall loss are selected. These locations typically include bends, tees, and elbows or other components that initiate a change in the direction of flow or result in turbulence. It is important to note that the adjacent straight runs of piping downstream of these fittings should also be included.

The second phase involves an on-site inspection where a grid system is permanently mapped around the entire circumference and length of the fittings. Wall thickness values are then ultrasonically measured and recorded at each grid point. The wall thickness values are very carefully transcribed into a computer database. This initial data are compared with the nominal and calculated minimum wall thickness requirements to identify any areas of significant thinning. Areas of gross wall loss are recommended for repair or replacement. By comparing the current wall thickness data to the nominal wall thickness, rough estimates of the wall loss rates can be determined.

The final phase of the program is to reinspect the same areas after two to three years of additional service. It is important that this reinspection will be performed very carefully, such that the new results can be compared to the prior baseline results, and wall thickness loss rates can be calculated. Based upon the results of these evaluations, intelligent preventive and predictive maintenance schedules can be derived.

Flow-Assisted Corrosion (FAC) is also known as Erosion Corrosion (EC). It affects a large number of systems in modern steam electric generating facilities. Increases in flow rates associated with larger generating units and improved oxygen control have provided the environment for FAC to occur.

When ASTM Specification A-106, Grade B or Grade C carbon steel and other mild steels are exposed to water, the initial reaction is:

$$Fe + 2H_2O \rightarrow Fe^{+2} + 2OH^{-1} + H_2$$

This reaction is then followed by:

$$3Fe^{+2} + 4H_2O \rightarrow Fe_3O_4 \text{ (magnetite)} + 4H_2$$

The magnetite forms a protective oxide layer on the surface of the metal.

The second reaction (formation of magnetite) is dependent on temperature, pH and oxygen concentration. In low oxygen feedwater this reaction proceeds relatively slowly. In areas of high turbulence or flow rate, such as elbows and tees, the Fe^{+2} produced in the first reaction, is carried from the surface of the material before the second reaction can occur. Consequently, the protective oxide layer does not develop and the underlying metal can continue to corrode at a relatively high rate. Corrosion rates on the order of 0.04" per year are considered high.

As mentioned, flow rates are the primary cause of the erosion. The flow patterns are inherent to the piping system and result from the piping geometry and the operational characteristics of the feed pumps.

Industry wide design practices for piping geometry, fluid velocity and additional wall thickness allowances to address FAC or EC in piping systems do not exist. It is generally left to the designer to use "good engineering practices" in the design of flow path geometry. "Target" velocities in Boiler Feedwater piping systems are normally in the range of 10 to 15 feet per second. However, velocity is typically not a primary design consideration.

Feedwater chemistry is another factor that affects the susceptibility of piping to FAC. Two parameters in particular are oxygen and pH. Flow-Assisted Corrosion is specifically active in piping systems containing water with the following chemical parameters:

Free Oxygen (0_2): 0 to 20 ppb

pH: 7.0 to 9.2

General Comments on Deaerators

Cracking in deaerator heaters and/or deaerator storage tanks is typically the result of mechanical fatigue or mechanical shock conditions.

For reference purposes, fatigue is a failure mode in which the failure of a component is caused by the repeated application of a stress. The stress is below the yield strength of the material from which the component is manufactured or fabricated. (This stress, if applied only once, would not be expected to produce failure of the component. It is only after repeated application of the stress that failure occurs.)

The mechanical fatigue is the result of cyclic stresses created by such operating conditions as full load rejection, temperature/pressure fluctuations, and water hammer.

Full load rejection occurs when the turbine trips and turbine extraction steam is lost. This may cause flooding of the downcomers, resulting in water being blown upward against the heater trays. Trays may become dislodged and in some cases, bent or broken beyond repair.

Moreover, when a unit trips, the pressure is reduced inside the deaerator heater and storage tank, resulting in steam flashing. This produces a water hammer effect, which will result in mechanical shock loading of the deaerator heater and storage tank, the pipe connections and the structural supports. These shock conditions may introduce stresses of as much as 30,000 psi. Flow-induced vibrations or water hammer may also occur in the piping connected to these vessels.

Severe stresses in the deaerator heater or storage tank can occur from temperature/pressure fluctuations resulting from either an influx of cold water or a unit trip. Large influxes of cold water entering the deaerator can cause a sudden drop in deaerator pressure and a subsequent flashing of water in the deaerator storage tank. Again, the result is movement and distortion of internal components in the deaerator heater as well as mechanical shock loading of the deaerator storage tank. To prevent this condition, the deaerator storage tank level control should be tuned to respond slowly to minor level variations.

Water hammer may also occur when high-temperature condensate comes in contact with cooler make-up water. The result is damage to deaerator internals, seams, and supports.

Necessary precautions include cooling the returning condensate either through the direct injection of cool make-up water or through a make-up heat exchanger.

In some instances, where the cracks have been widened by slight corrosion, failures have been attributed to corrosion fatigue, even though mechanical fatigue or shock represents the actual primary cause. Nevertheless, magnetite (Fe_3O_4) generally is formed in the fatigue cracks. Thus, magnetite formation is considered a contributor to the cracking of deaerator heaters and deaerator storage tanks.

Magnetite formation, in conjunction with deep oxygen pitting, will not result in cracking or fissuring. Even where shells have developed pits of depths of 30% to 50% of the wall thickness with magnetite deposits in the pits, cracking has not occurred. In a few instances, caustic stress corrosion cracking has been apparent. These types of cracking, however, generally appear to represent exceptional cases.

Temperature cycling can also cause or contribute to cracking alongside or across welds with high residual stress levels. However, cycles involving 100°F temperature variations generally would require a million cycles for crack initiation to occur. A 200°F temperature differential would require approximately 100,000 cycles, whereas a 400°F to 500°F temperature differential in each cycle would require approximately 10,000 cycles for cracking to occur.

Cracking in deaerator heaters and storage tanks has also been attributed to caustic stress corrosion. This cause, however, represents an exceptional case as the presence of caustic or alkaline water is required. Caustic invasion of a feedwater system typically occurs when a breach of the piping is made because of operator error. The feedwater may also become alkaline due to additive water treatment chemicals. The attemperator deaerator heater water supply is de-ionized water, treated with hydrazine. The pH of the water supply is such that caustic stress corrosion is generally precluded under normal operations.

Inspections also frequently reveal linear indications alongside welds which are completely unrelated to any of the above referenced mechanical fatigue, thermal fatigue, and/or stress corrosion-type mechanisms. Such linear indications can be the result of stress cracking, which can occur at the time the welds are made or soon thereafter. These cracks frequently are referred to as "cold" cracks.

Undercut along weld edges, incomplete fusion along weld edges or between weld beads, slag inclusions open to the surface of ground welds, etc., can also be revealed as linear indications during wet fluorescent magnetic particle examinations. These are frequently confused with progressive cracking, but generally are of no consequence to the integrity of the deaerator heaters, deaerator storage tanks, flash tanks, and related equipment.

Linear indications in the base material adjacent to welds can represent surface laps or slivers in the original plate materials from which the vessel was fabricated. These indications are frequently interpreted erroneously as progressive cracks. Surface laps and slivers normally are not critical to the integrity of the vessel, and typically do not result in progressive cracking conditions.

Water or steam erosion of the shell has caused a number of failures of deaerator heaters and storage tanks. While erosion conditions have resulted in cracks extending through the shell, ruptures have not occurred. When erosion is the principal cause of failure, cracks have not been found to develop until the wall thickness has been reduced to less than 10% of the original shell thickness.

Erosion in pressure vessels has been linked to three different mechanisms. The first cause of erosion, often seen in cyclical units, is erosion due to the degradation of the internal structures of the deaerator heater. Often trays and tray supports become misaligned causing changes in the flow patterns. These new flow patterns cause erosion in the affected areas by superheated water impinging on the shell of the vessel at an unprotected location.

The second form of erosion is based upon poor design. This occurs when a baffle plate or other flow direction device is installed adjacent to a nozzle without thought to the effect. Many instances have been seen where the resultant contact location is the shell of the vessel adjacent to the nozzle. Baffle plates have been installed to remove wear on a stainless steel liner, which is extremely impervious to erosion and is diverted to impinge upon the adjacent shell. Typically, the cracking conditions resulting from erosion have occurred in conjunction with this failure mode.

The third cause of erosion is due to operational deficiencies. Often, the entering steam temperature is too low. This low-temperature steam, upon entering the vessel, will condense, experiencing a decrease in pressure. This will result in droplet-type impingement upon the shell of the deaerator. This form of erosion is typically the most difficult to correct as the properties of the inlet steam, and inlet water have been calculated previously by the deaerator manufacturer and are critical in the operation of the unit.

CONCLUSIONS AND RECOMMENDATIONS

Thielsch, Inc. performed an inspection of the high-energy piping systems and pressure vessels in Unit No. 2 at the J.S. Cooper Generating Station in March of 2024. Based upon the results of the inspection, the following conclusions and recommendations are offered:

Main Steam Piping System

- Linear fatigue-type indication at hanger attachment weld No. MSH-5 removed at 1/8"; Acceptable. Monitor during future inspections.
- No pipe swelling or wall thinning was noted.
- No subsurface indications were detected.
- Operating in Class 1 creep mode.
- Piping materials have consumed less than 20% of their useful life.
- The Main Steam piping system is considered suitable for continued service under the intended operating conditions.
- A similar inspection should be performed after three to five years of additional service (2027 to 2029).

Hot Reheat Piping System

- Transverse and linear fatigue-type indications at penetration No. P-3 removed with light grinding; Acceptable. Monitor during future inspections.
- No pipe swelling or wall thinning was noted.
- Inclusion type sub-surface indication detected at girth weld No. GW-7; Acceptable. Appears to be an original defect from manufacturing. Monitor during future inspections.
- Operating in Class 1 creep mode.
- Piping materials have consumed less than 20% of their useful life.

- The Hot Reheat piping system is considered suitable for continued service under the intended operating conditions.

- A similar inspection should be performed after three to five years of additional service (2027 to 2029).

Cold Reheat Piping System

- No evidence of significant service-related deterioration was revealed.

- No pipe swelling or wall thinning was noted.

- No subsurface indications were detected.

- The Cold Reheat piping system is considered suitable for continued service under the intended operating conditions.

- A similar inspection should be performed after five years of additional service (2029).

Boiler Feedwater Discharge Piping System

- Severe undercut at previous repair in crotch of penetration No. P-1; Acceptable. Monitor during future inspections.

- No pipe swelling was noted.

- No significant wall thinning consistent with FAC was noted.

- No subsurface indications were detected.

- The Boiler Feedwater Discharge piping system is considered suitable for continued service under the intended operating conditions.

- A similar inspection should be performed after five years of additional service (2029).

Condensate Line

- No evidence of significant service-related deterioration was revealed.
- No significant wall thinning consistent with FAC was noted.
- No subsurface indications were detected.
- The Condensate Line is considered suitable for continued service under the intended operating conditions.
- A similar inspection should be performed after five years of additional service (2029).

Deaerator Heater

- Multiple broken tray box support welds, stitch welds, and attachments welds. Multiple small cracks in tray box by nozzles on the north and south sides. Repair all noted tray box conditions before returning the unit to service.
- No significant wall thinning was noted.
- Subsequent to the recommended repairs, the deaerator heater is considered suitable for continued service under the intended operating conditions.
- A similar inspection should be performed after three years of additional service (2027).

Deaerator Storage Tank

- Linear fatigue-type indication at penetration No. P-4 removed with light grinding; Acceptable. Monitor during future inspections.
- No significant wall thinning was noted.
- The deaerator storage tank is considered suitable for continued service under the intended operating conditions.

- A similar inspection should be performed after three years of additional service (2027).

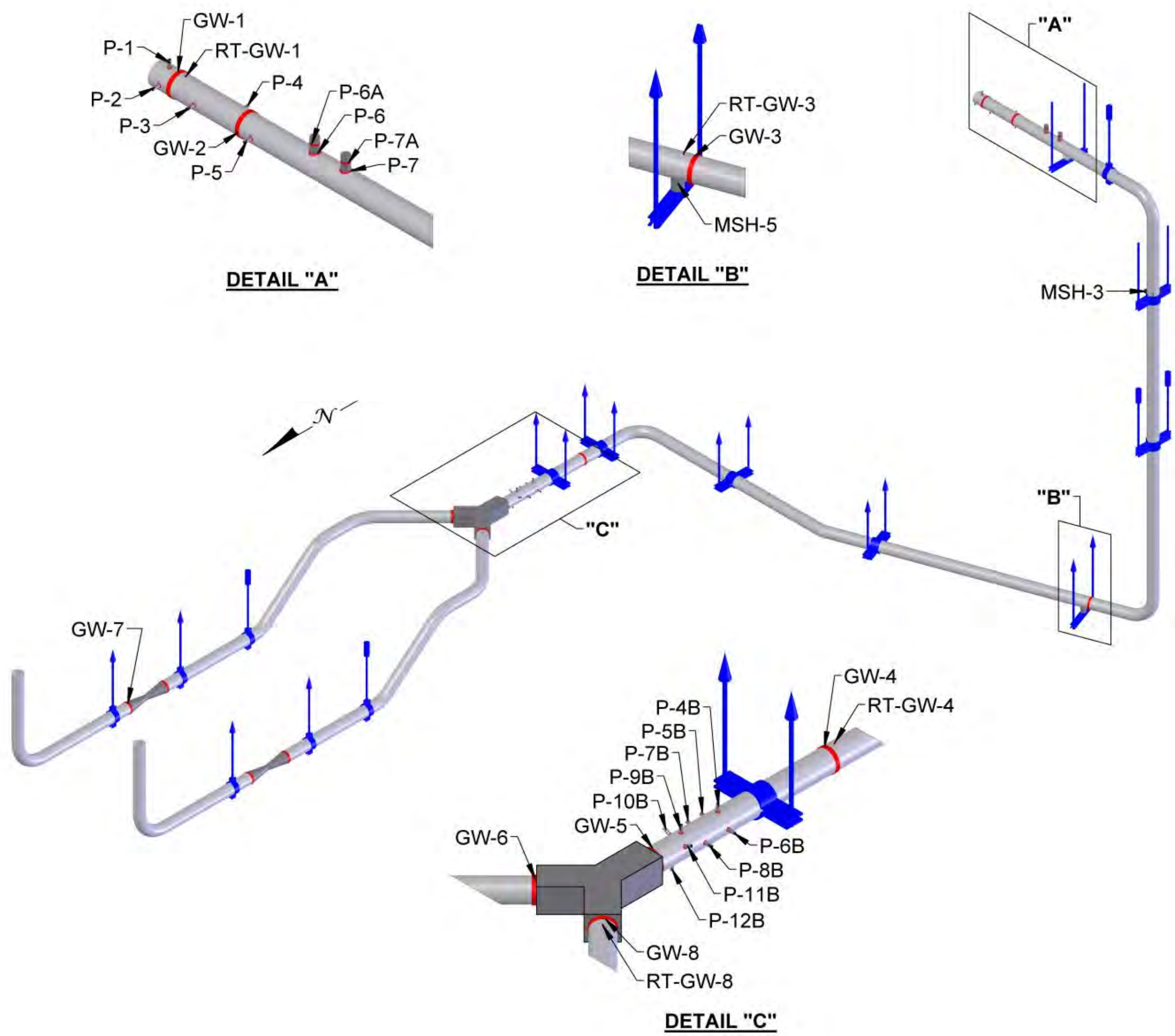
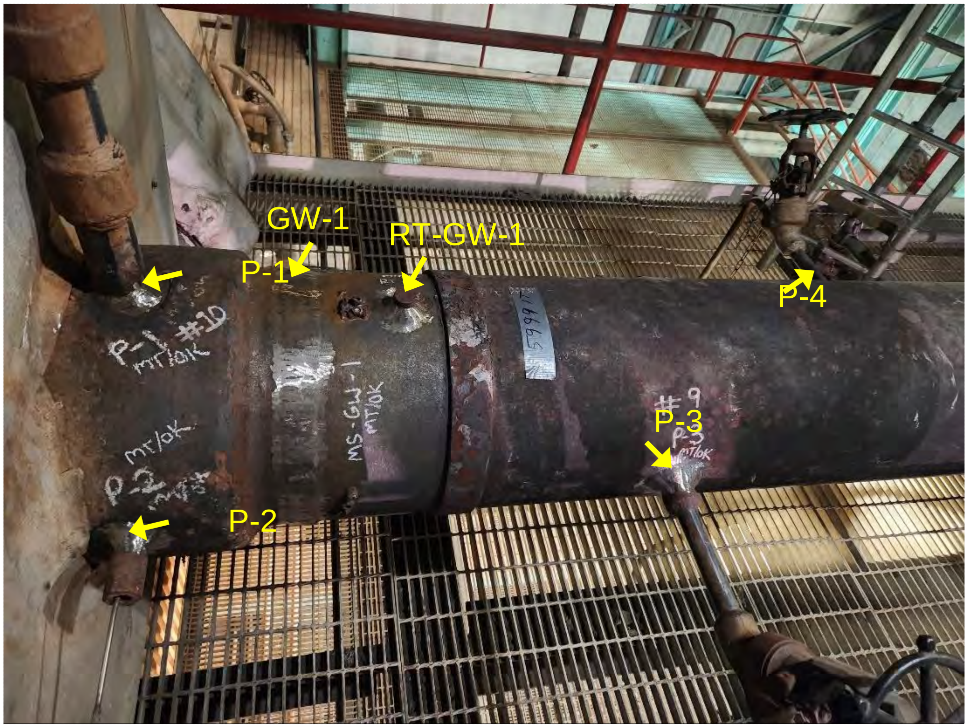


Fig. 1. Sketch of the inspection locations on the Main Steam piping system.

EASTERN KENTUCKY POWER COOPERATIVE (EKPC)
J.S. COOPER GENERATING STATION
UNIT NO. 2 - MAIN STEAM PIPING SYSTEM
JOB NO. 43-24-0331a

Thielsch
DIVISION OF THE RISE GROUP



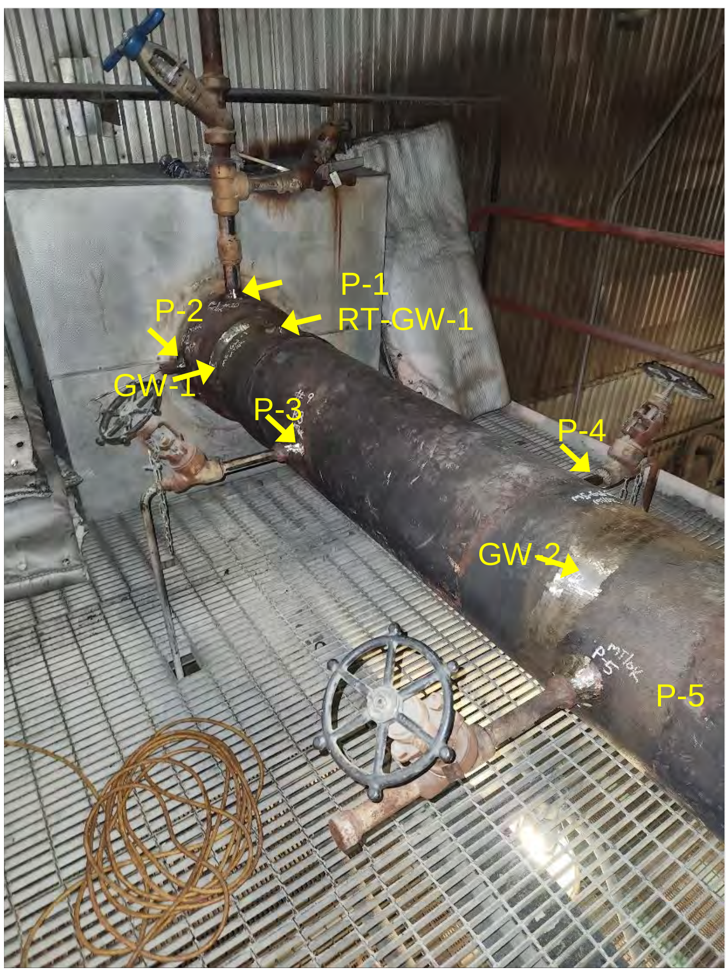


Fig. 2. Photographs of the inspection locations on the Main Steam piping system.

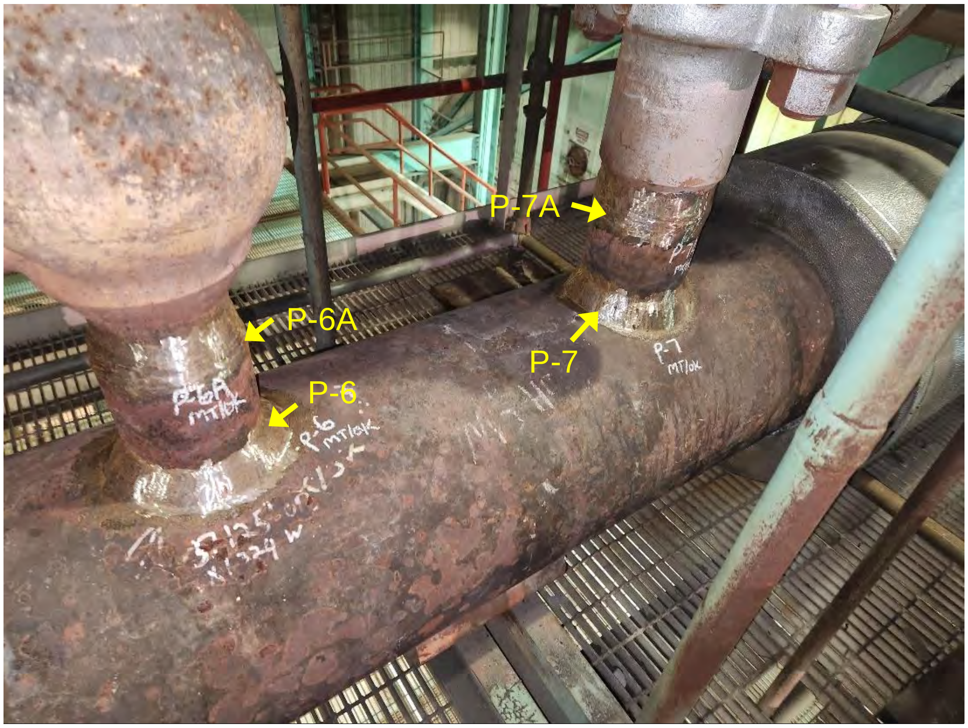
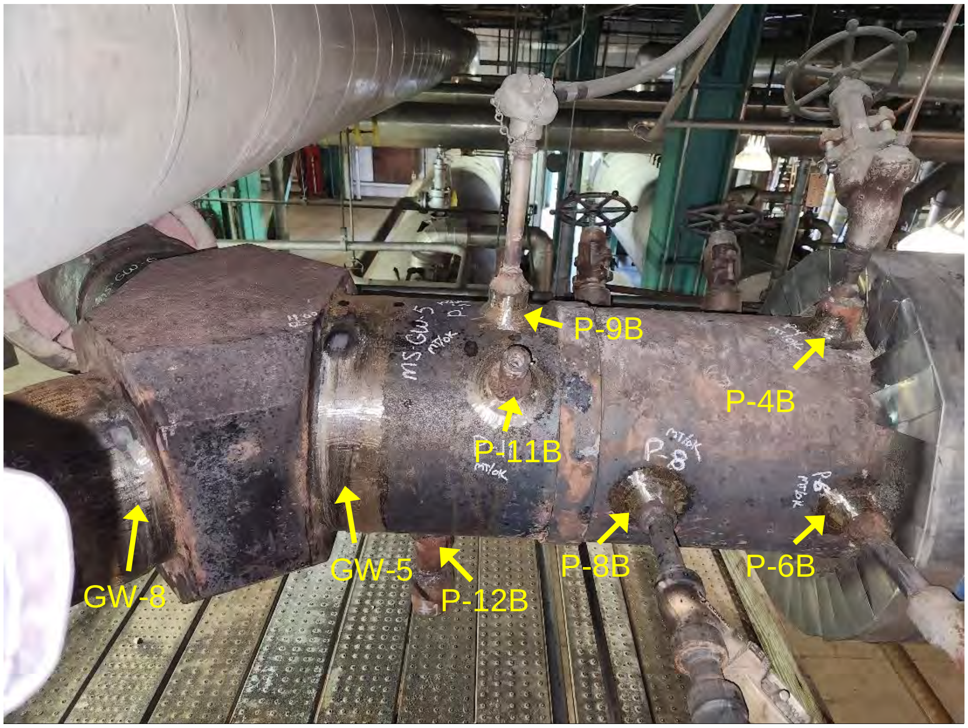


Fig. 3. Photographs of the inspection locations on the Main Steam piping system.

Fig. 4.

Photographs of the inspection locations on the Main Steam piping system.



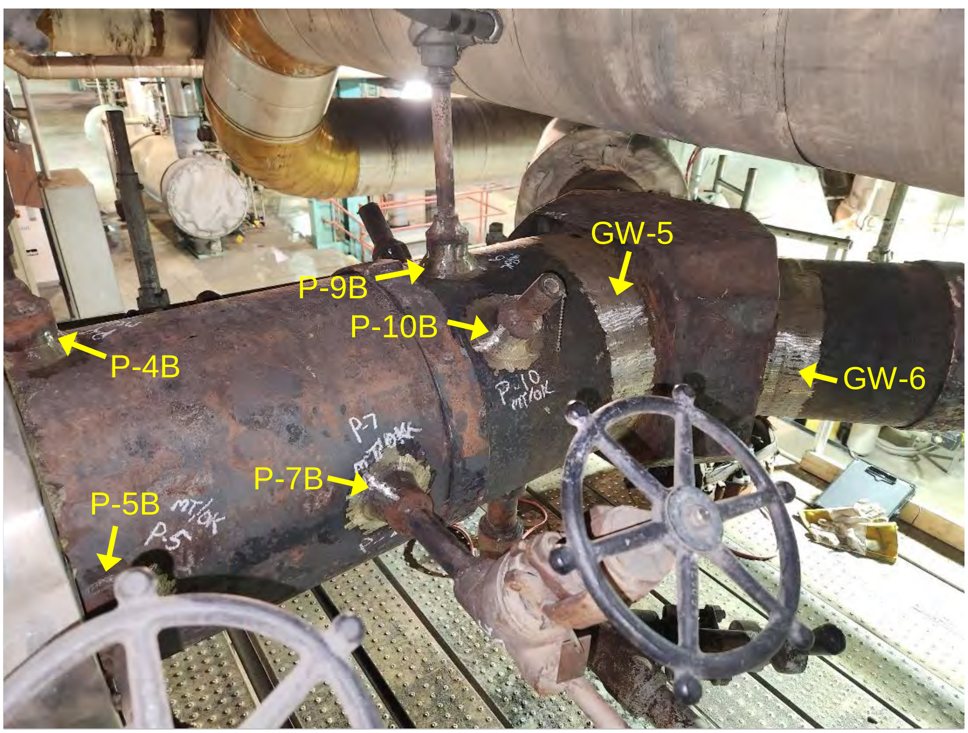
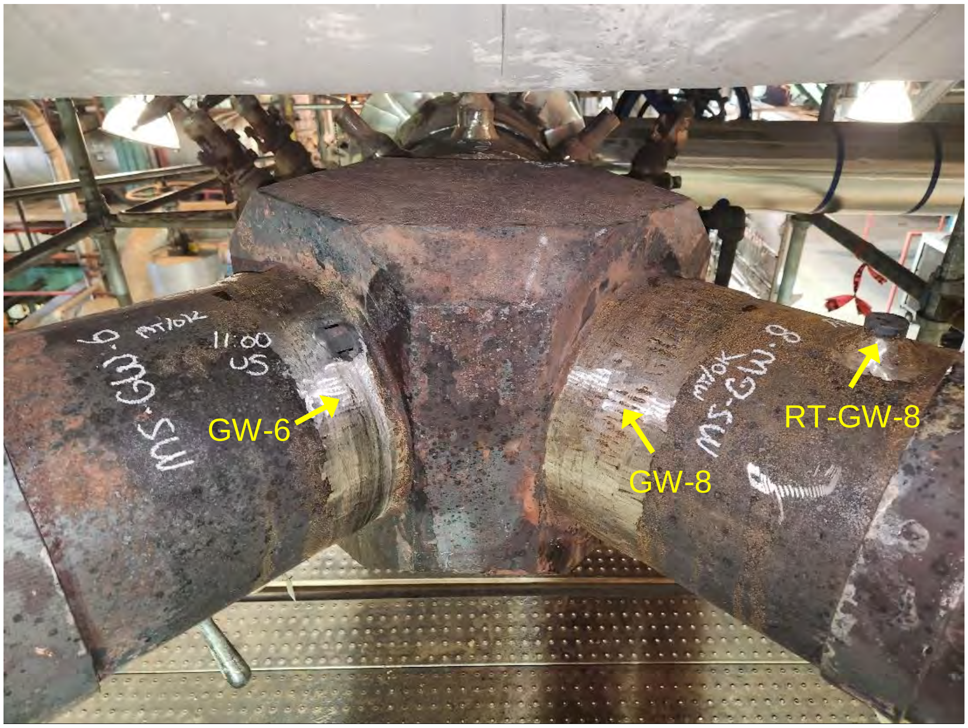


Fig. 5. Photographs of the inspection locations on the Main Steam piping system.



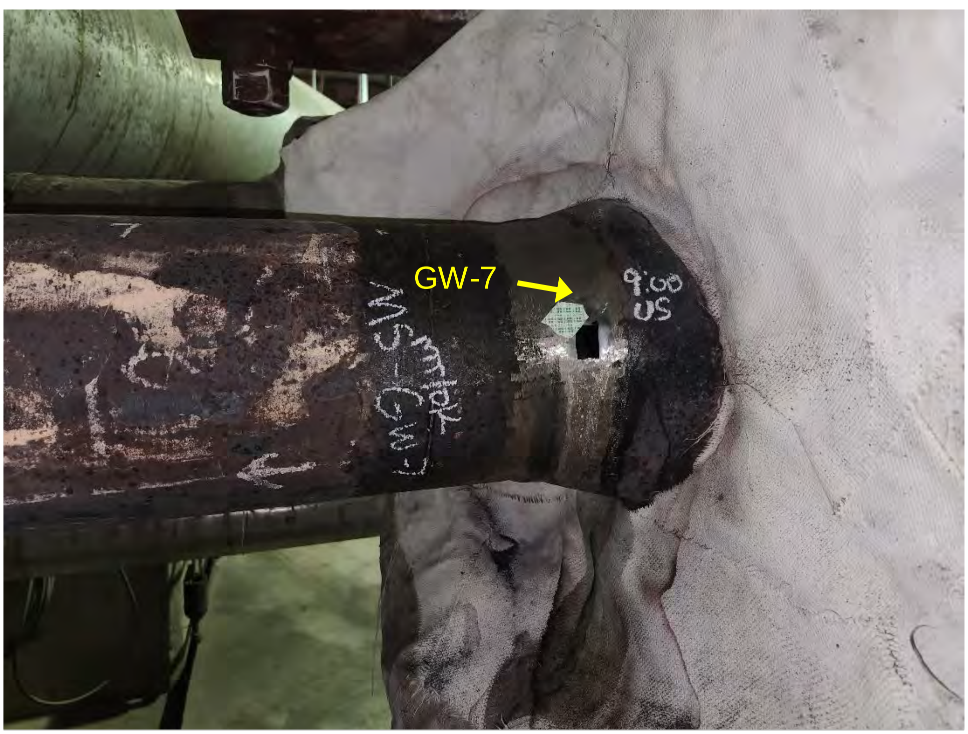
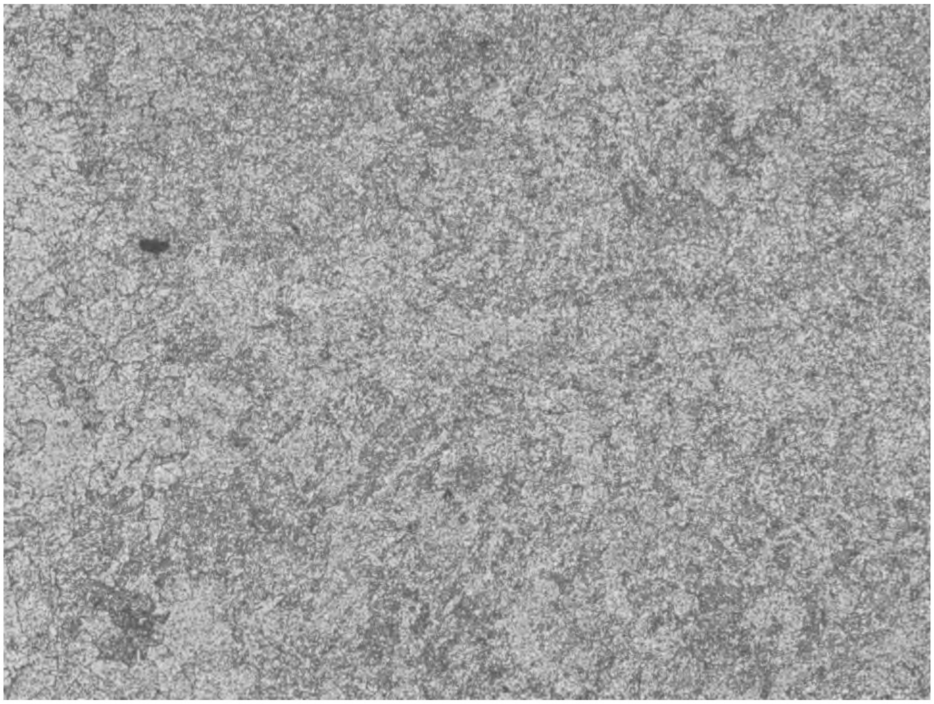


Fig. 6. Photographs of the inspection locations on the Main Steam piping system.

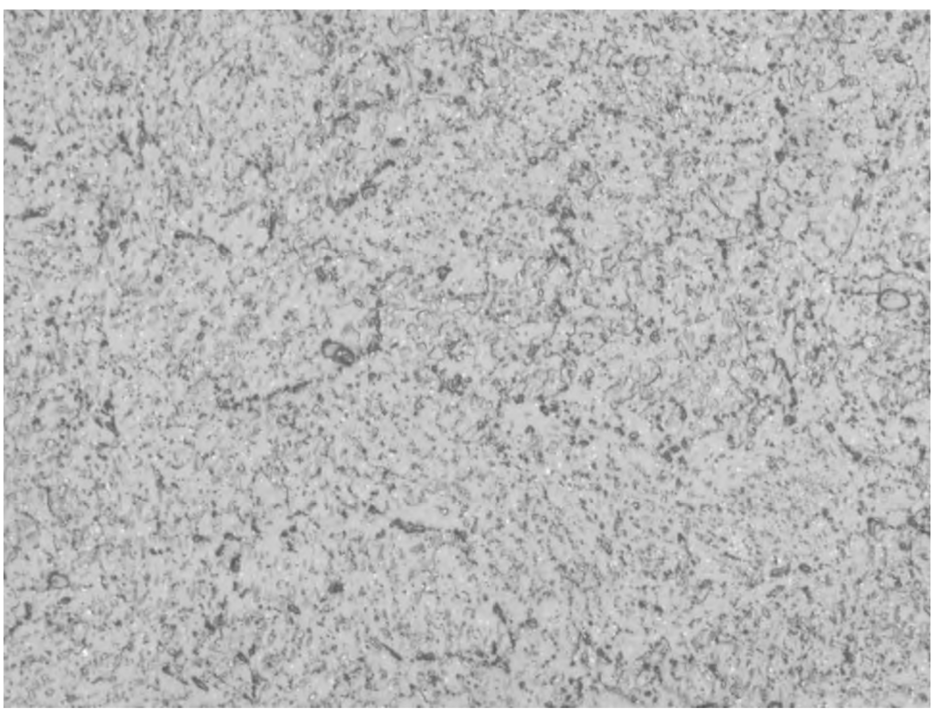
Fig. 7.

Photographs of the indication at hanger attachment No. MSH-5 on the Main Steam piping system.



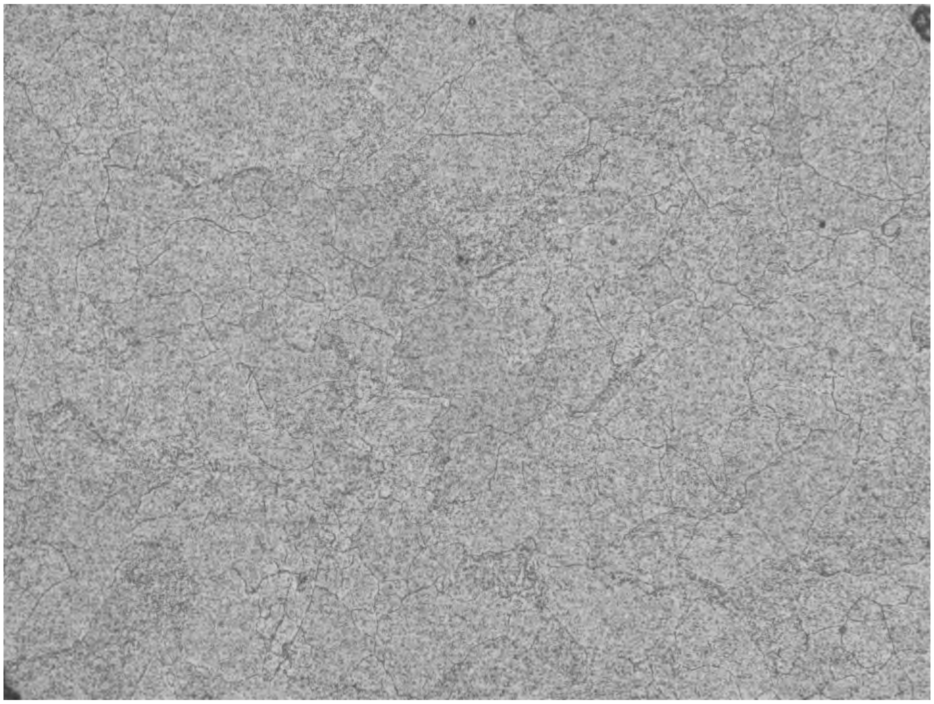
100X

Bainite and ferrite
microstructure



500X

Fig. 8. Replica No. MS-R1.



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Bainite and ferrite microstructure

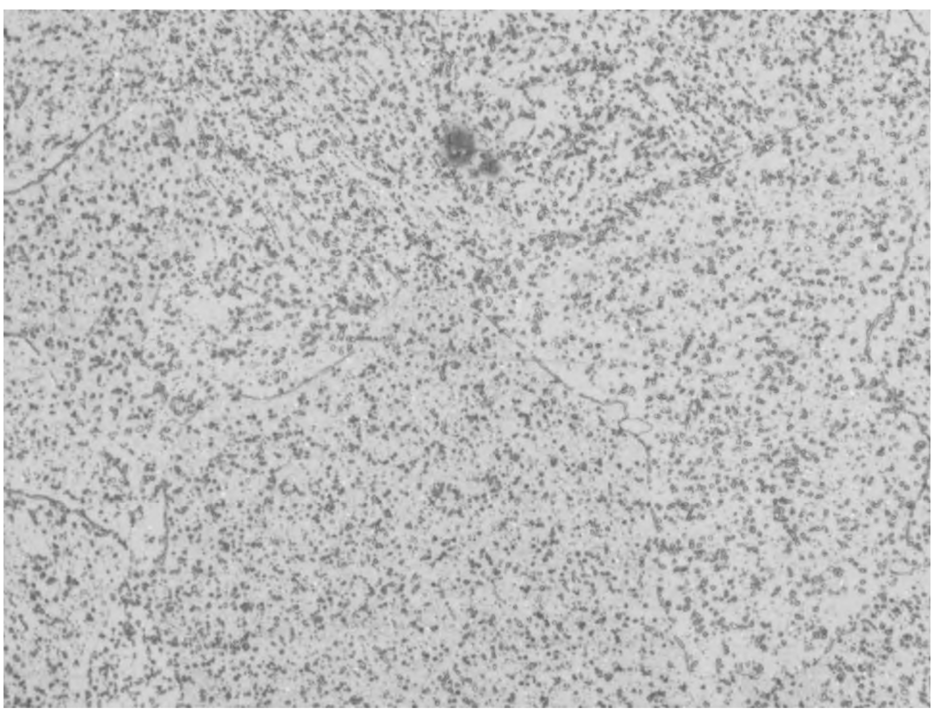

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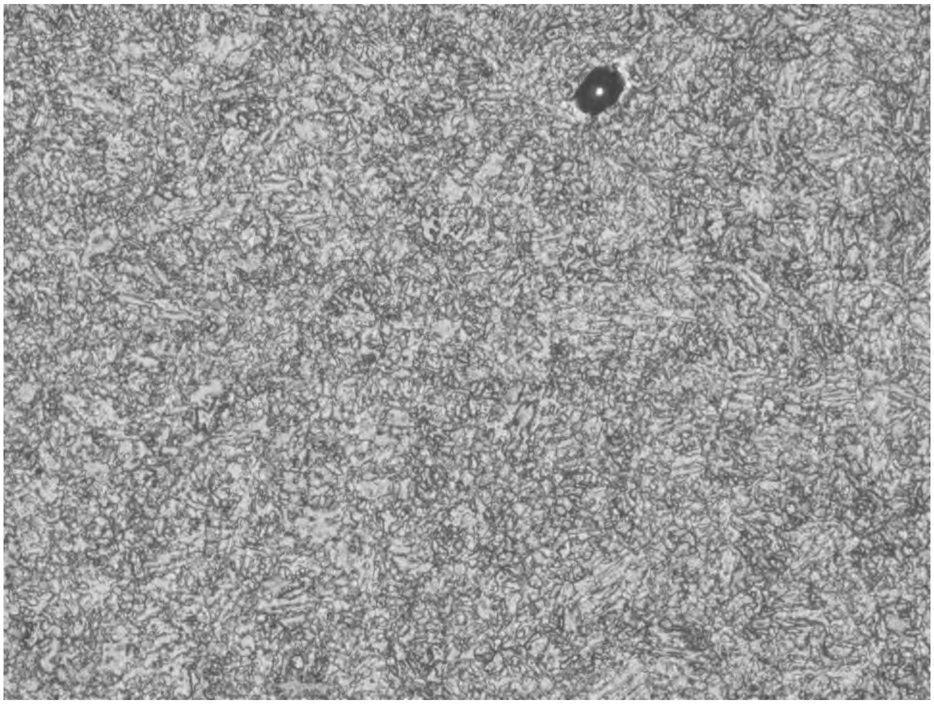
Fig. 9. Replica No. MS-R2.



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Bainite and ferrite microstructure

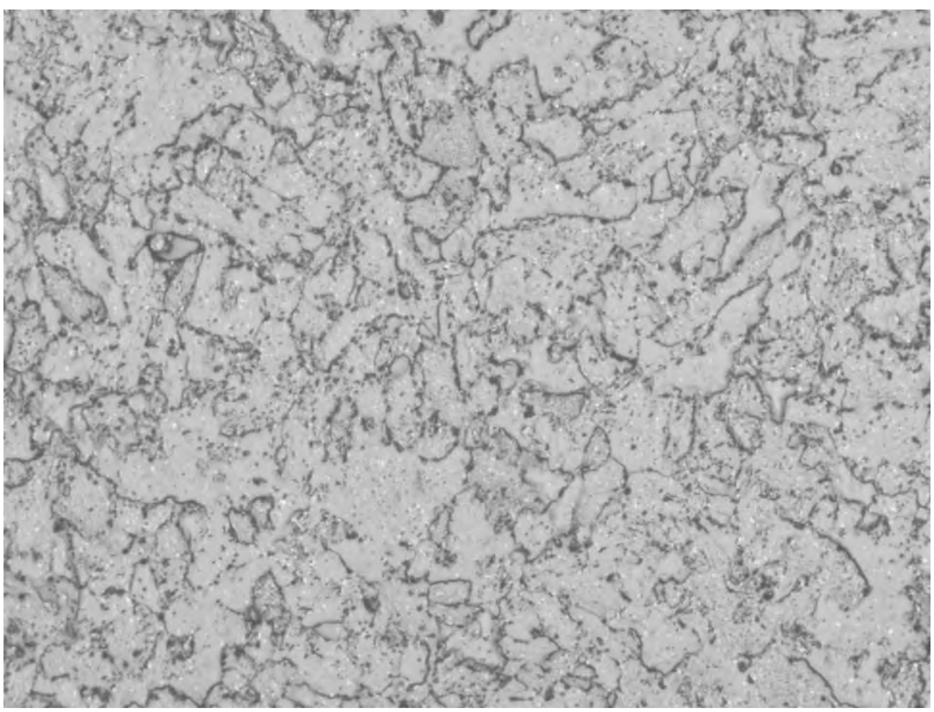

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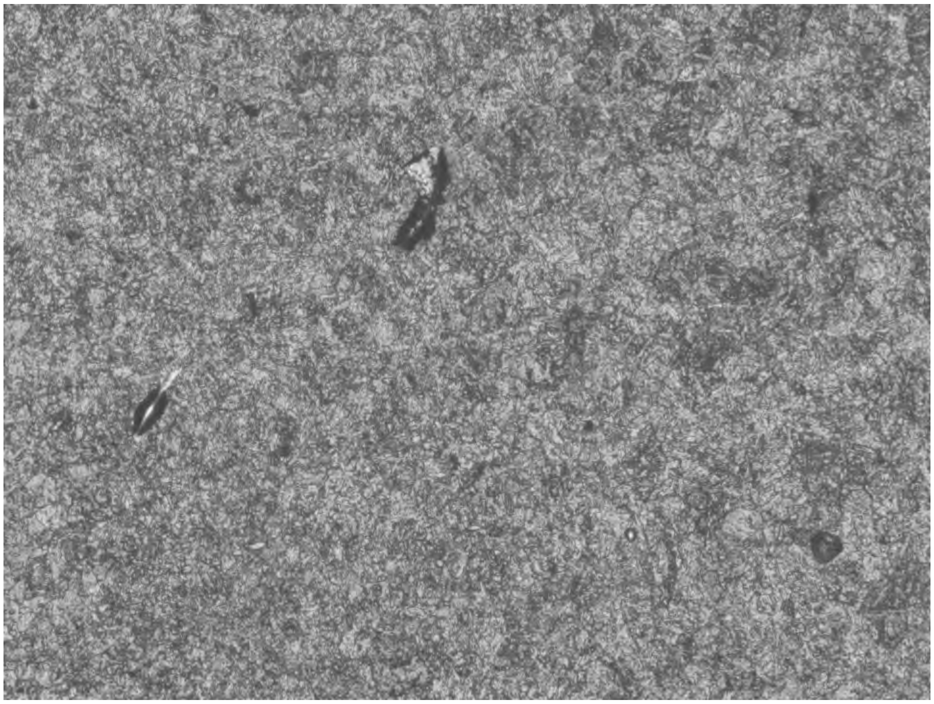
Fig. 10. Replica No. MS-R3.



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Bainite and ferrite microstructure

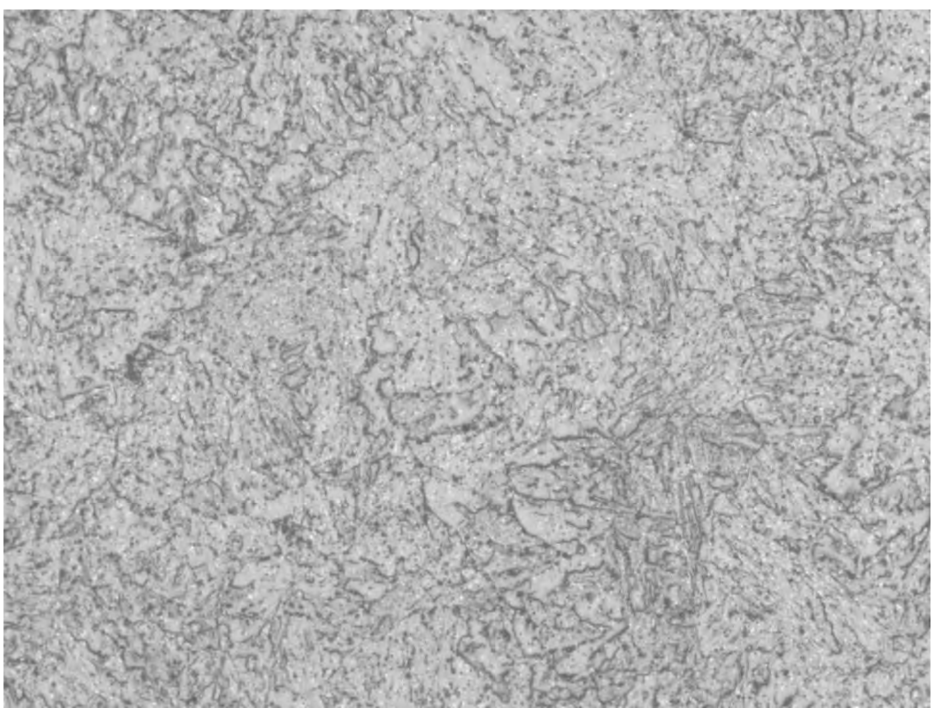

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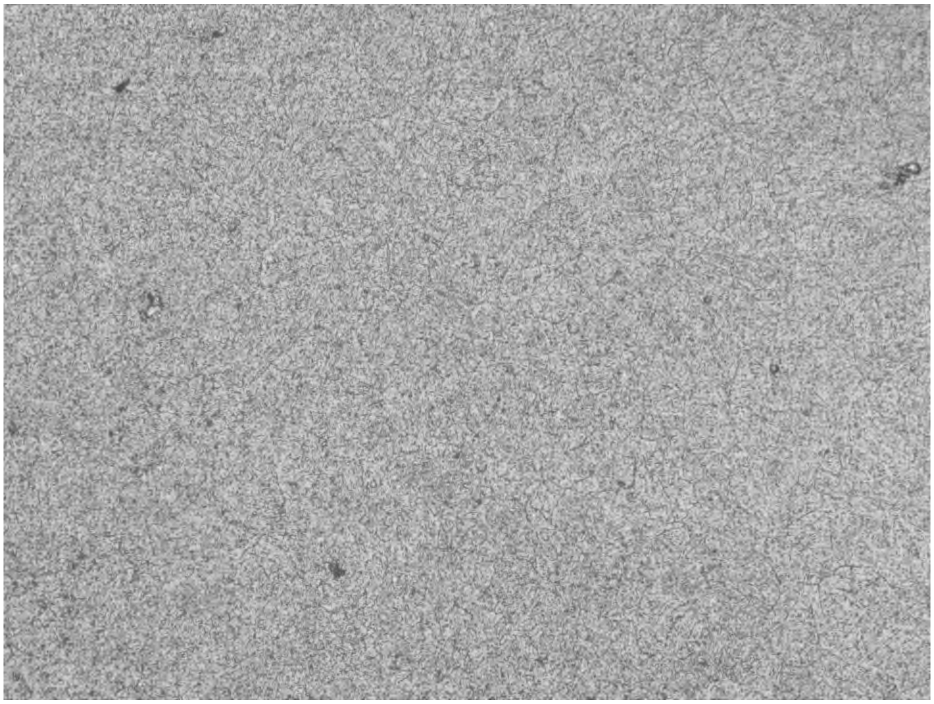
Fig. 11. Replica No. MS-R4.



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Bainite and ferrite microstructure

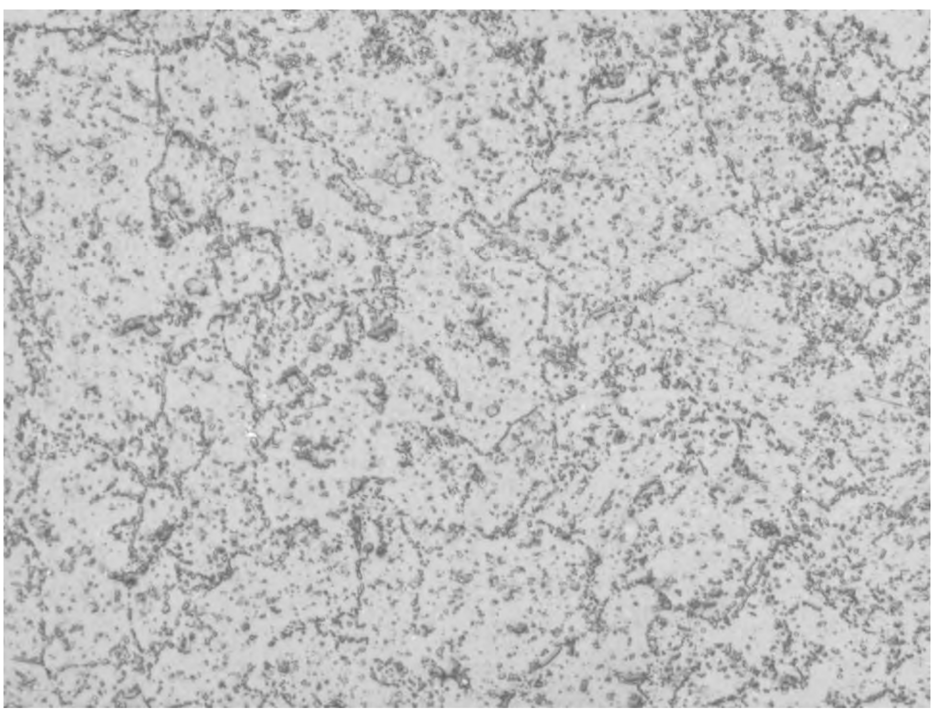

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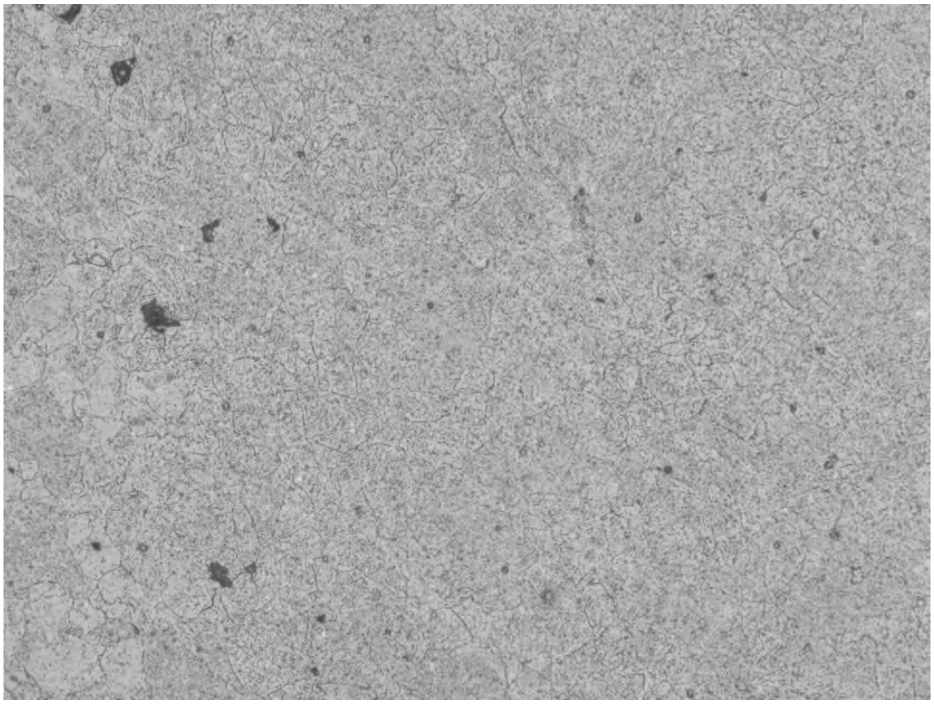
Fig. 12. Replica No. MS-R5.



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Bainite and ferrite microstructure

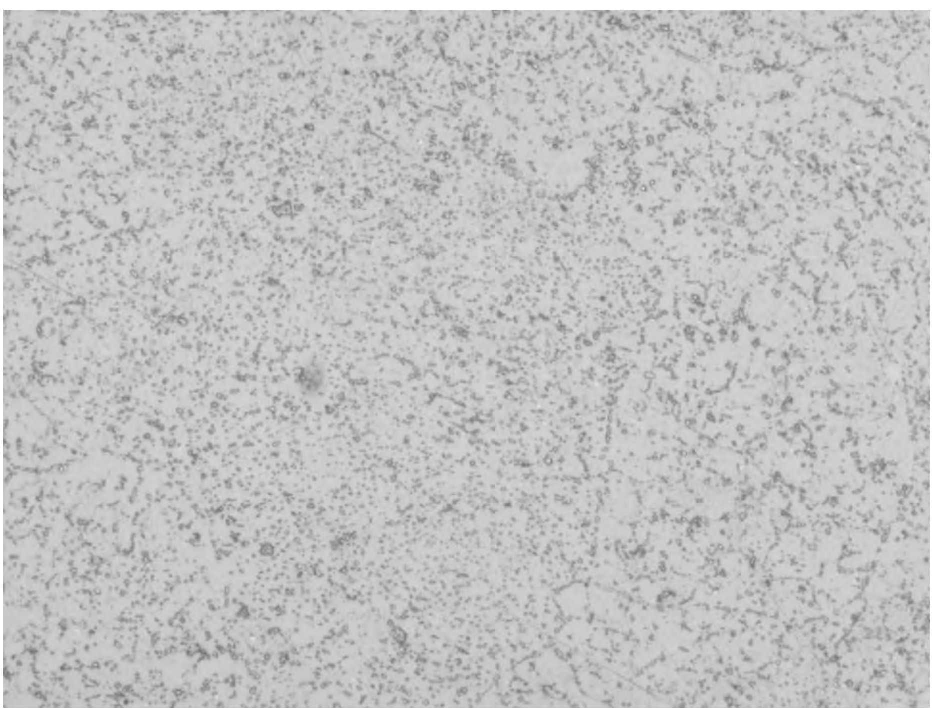

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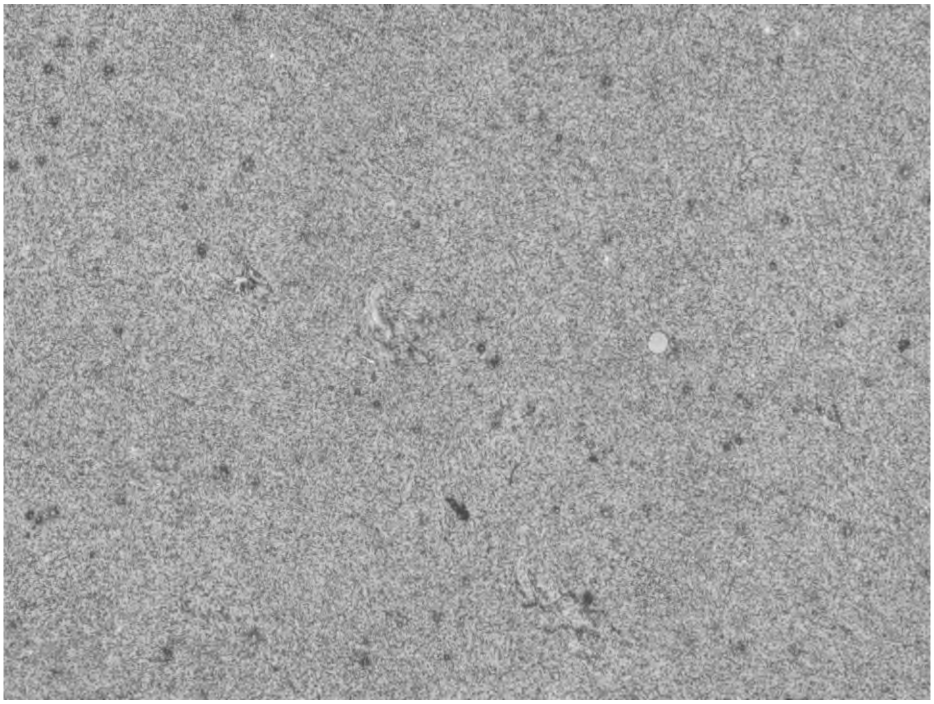
Fig. 13. Replica No. MS-R6.



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Bainite and ferrite microstructure

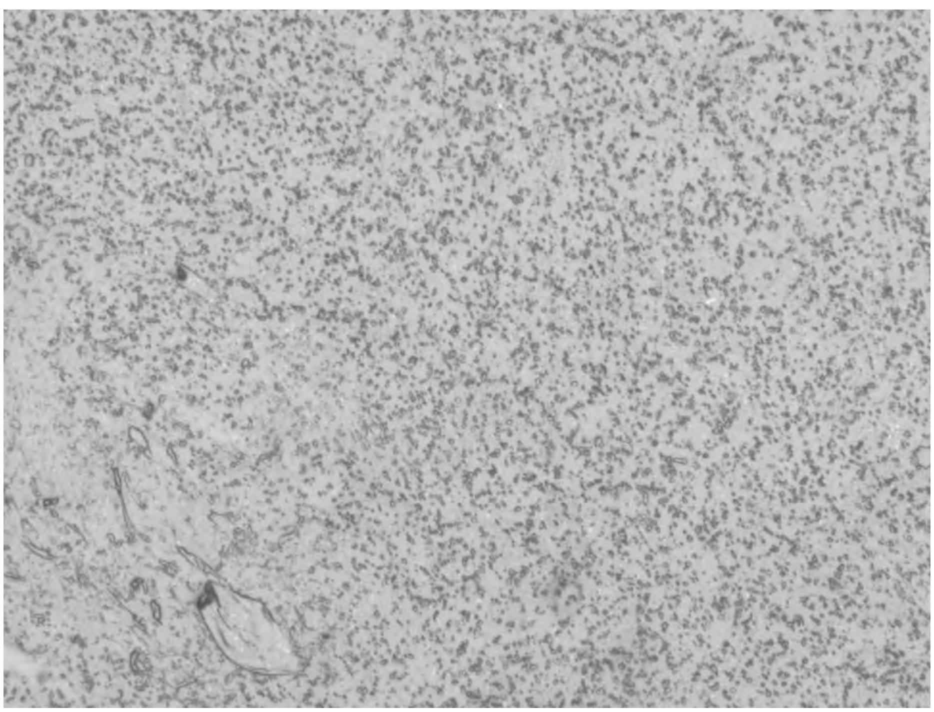

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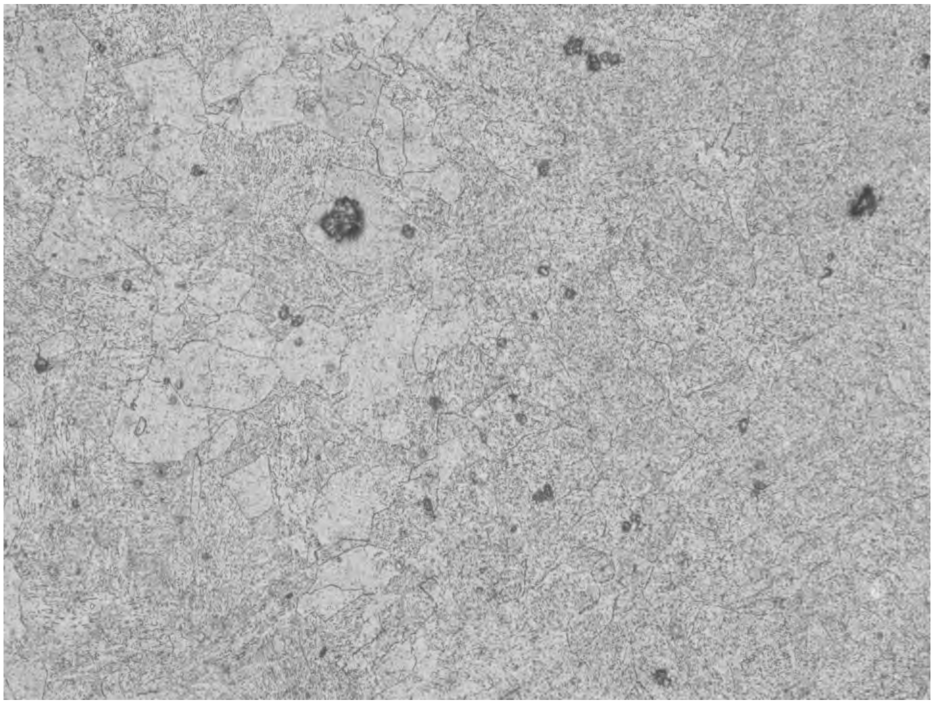
Fig. 14. Replica No. MS-R7.



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Bainite and ferrite microstructure

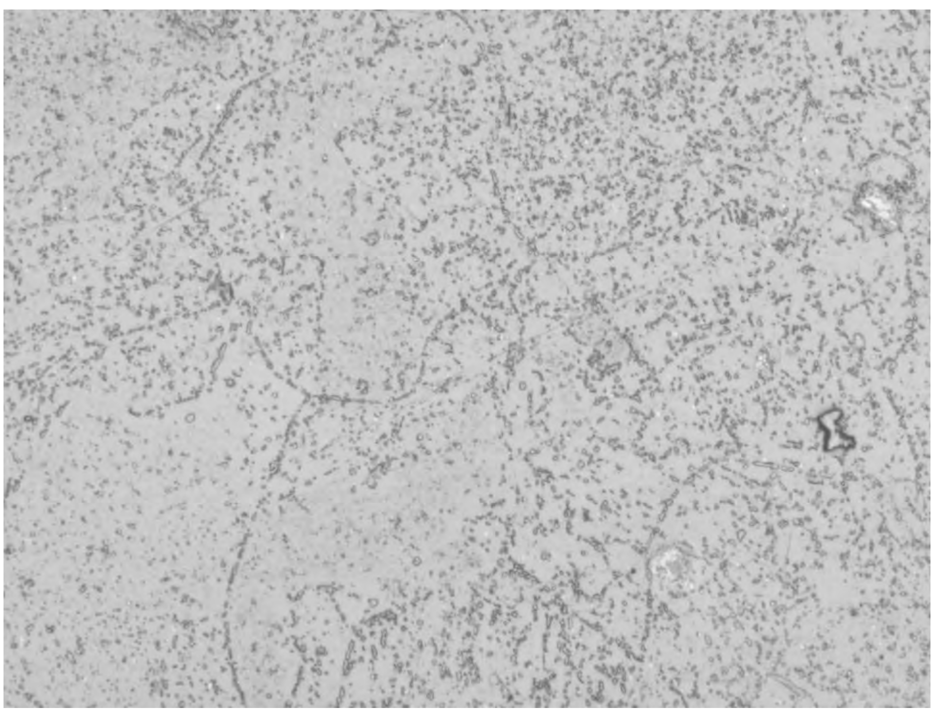

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Fig. 15. Replica No. MS-R8.

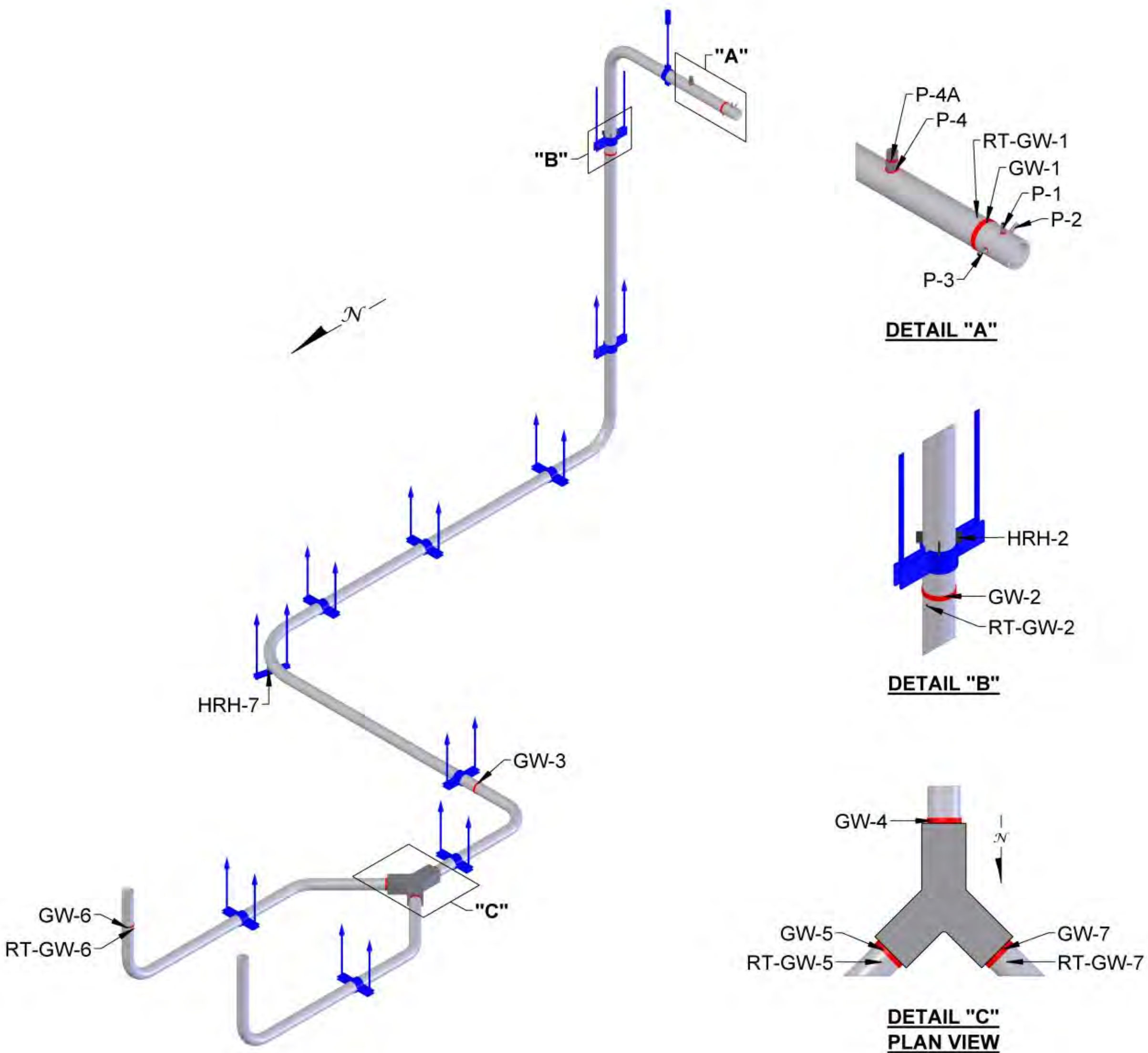


Fig. 16. Sketch of the inspection locations on the Hot Reheat piping system.

EASTERN KENTUCKY POWER COOPERATIVE (EKPC)
J.S. COOPER GENERATING STATION
UNIT NO. 2 - HOT REHEAT PIPING SYSTEM
JOB NO. 43-24-0331a

Thielsch
DIVISION OF THE RISE GROUP

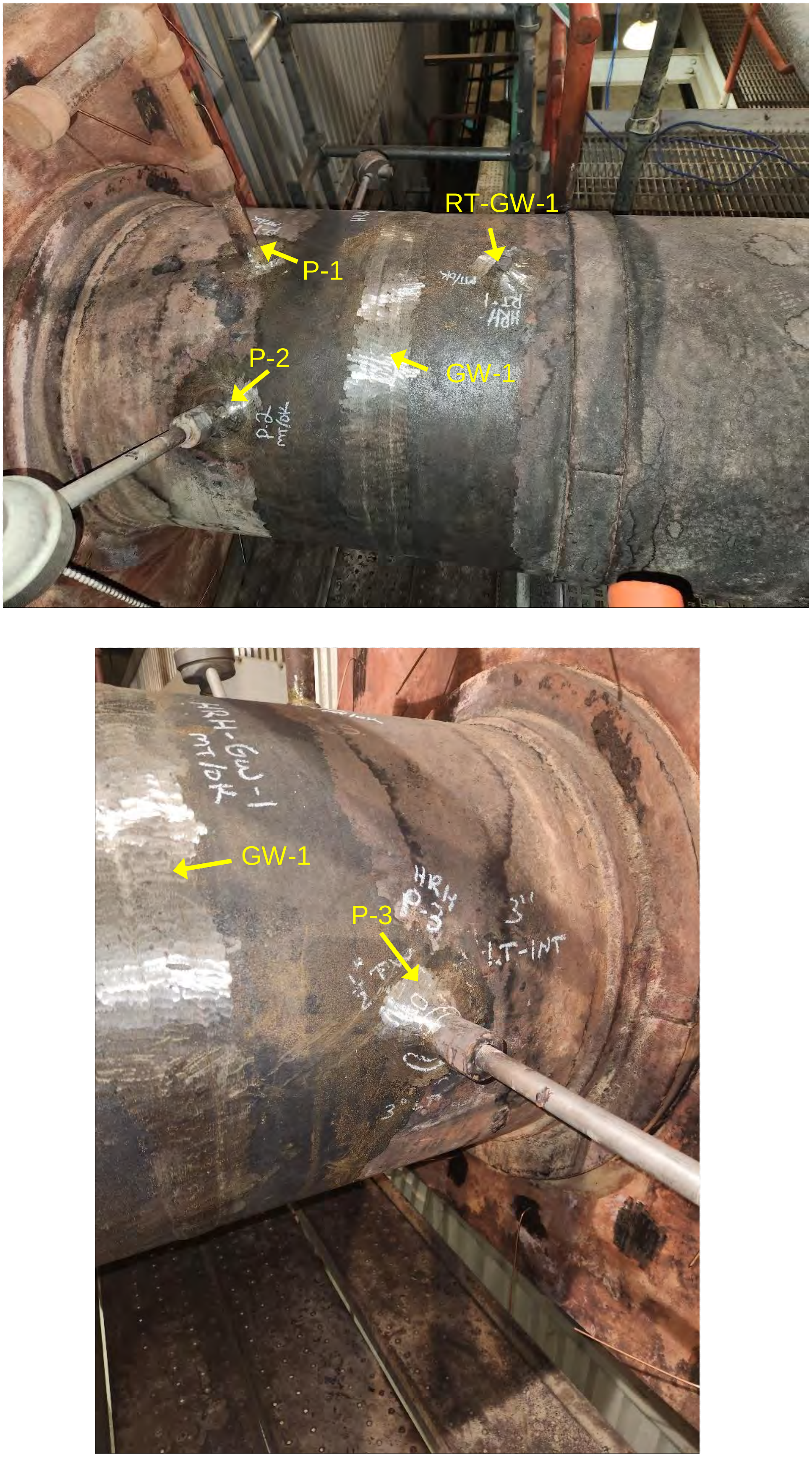


Fig. 17. Photographs of the inspection locations on the Hot Reheat piping system.

Fig. 18. Photographs of the inspection locations on the Hot Reheat piping system.

Fig. 19.

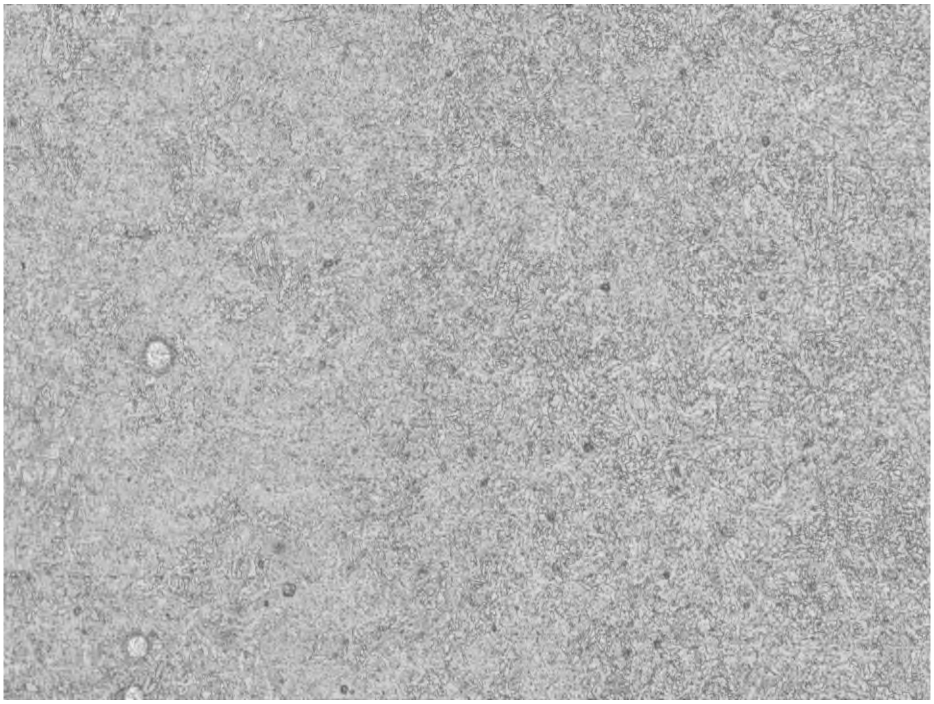
Photographs of the inspection locations on the Hot Reheat piping system.

Fig. 20. Photographs of the inspection locations on the Hot Reheat piping system.

Fig. 21. Photographs of the inspection locations on the Hot Reheat piping system.

Fig. 22.

Photographs of the indications at penetration No. P-3 on the Hot Reheat piping system.



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Bainite and ferrite microstructure

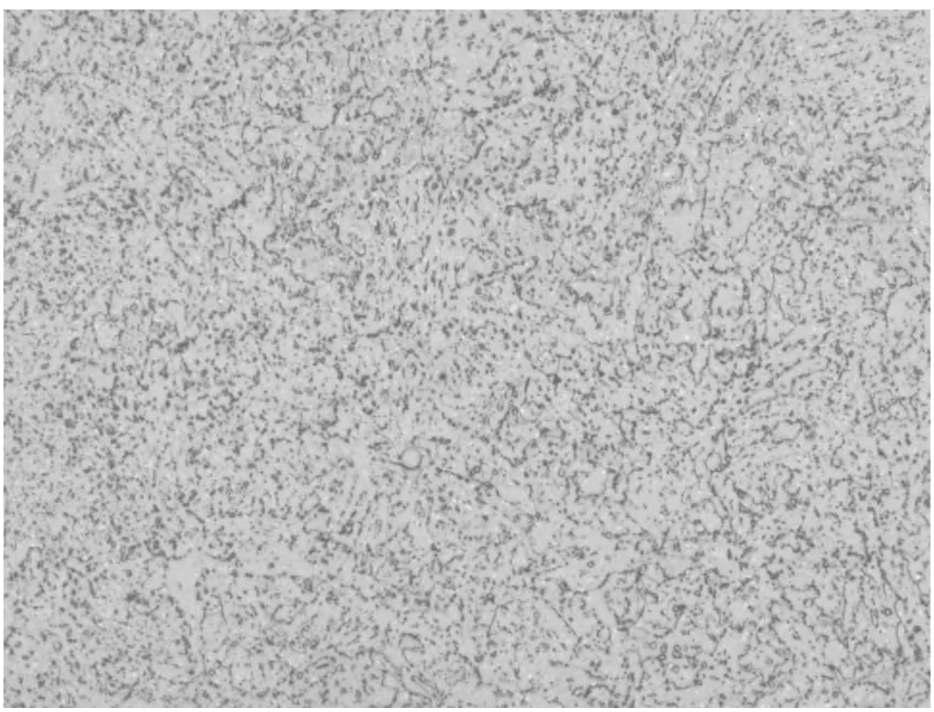

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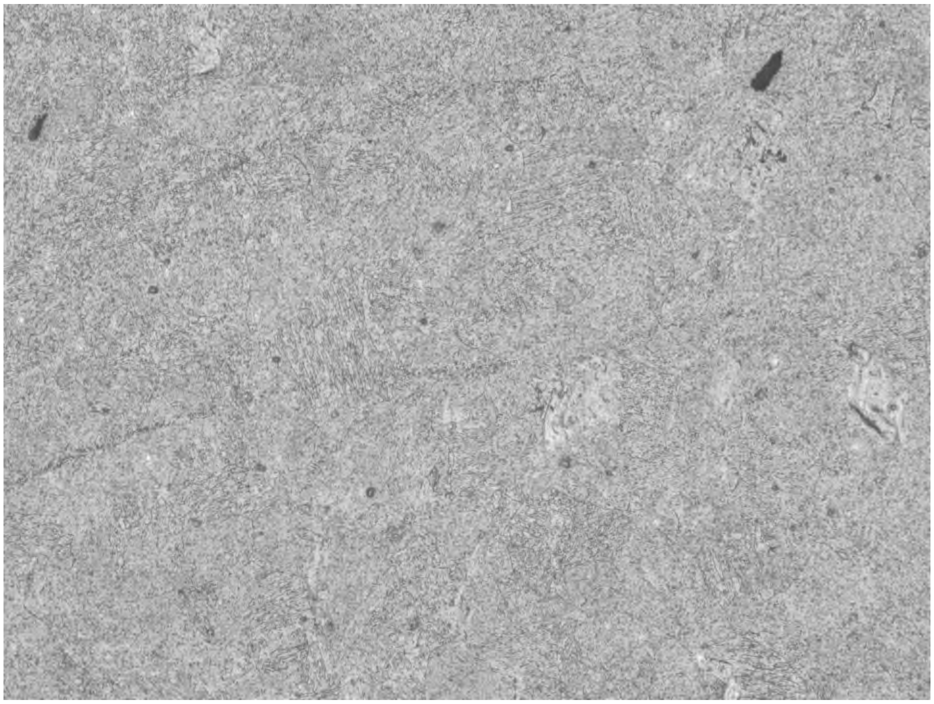
Fig. 23. Replica No. HRH-R1.



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Bainite and ferrite microstructure

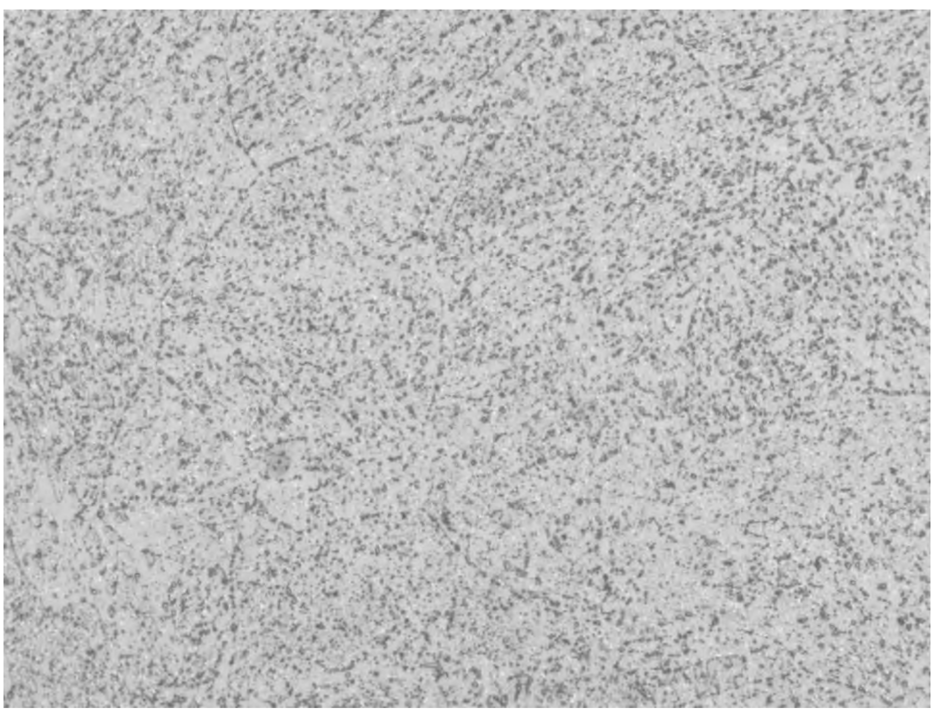

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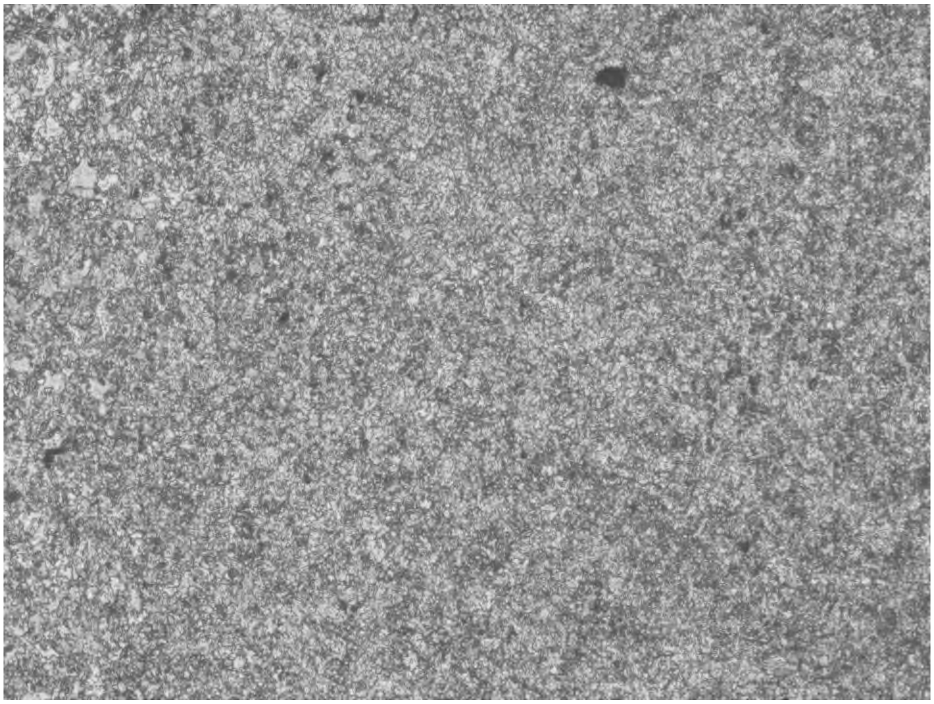
Fig. 24. Replica No. HRH-R2.



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Bainite and ferrite microstructure

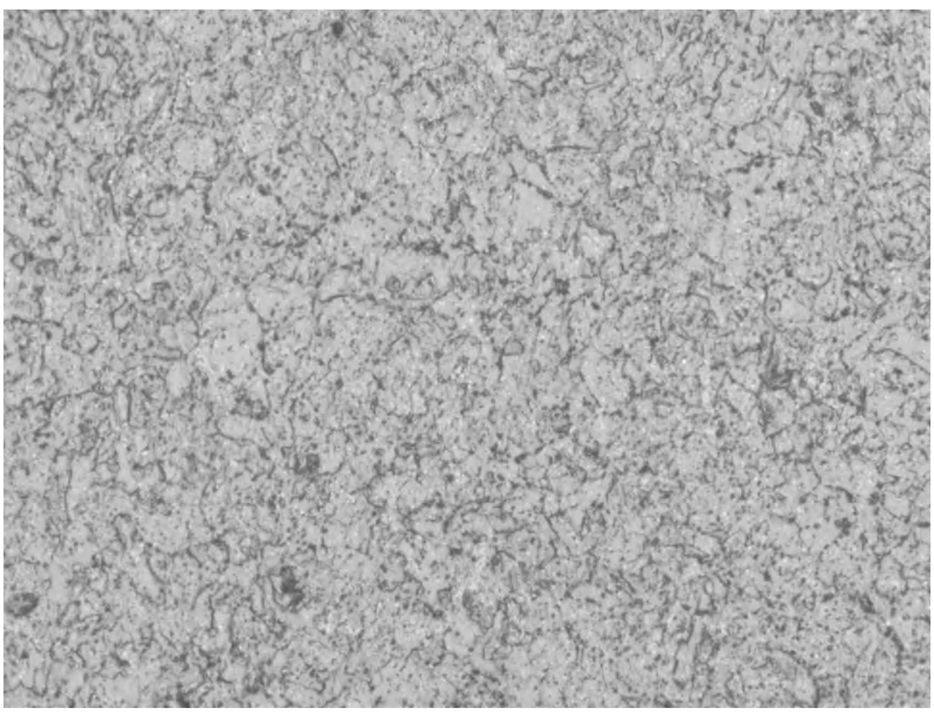

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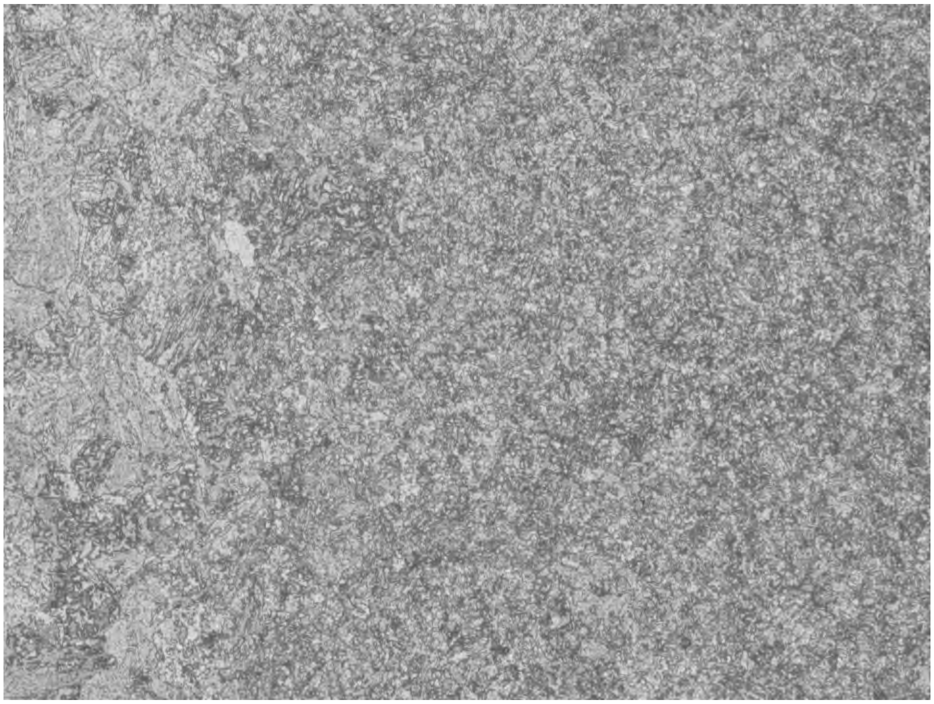
Fig. 25. Replica No. HRH-R3.



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Bainite and ferrite microstructure

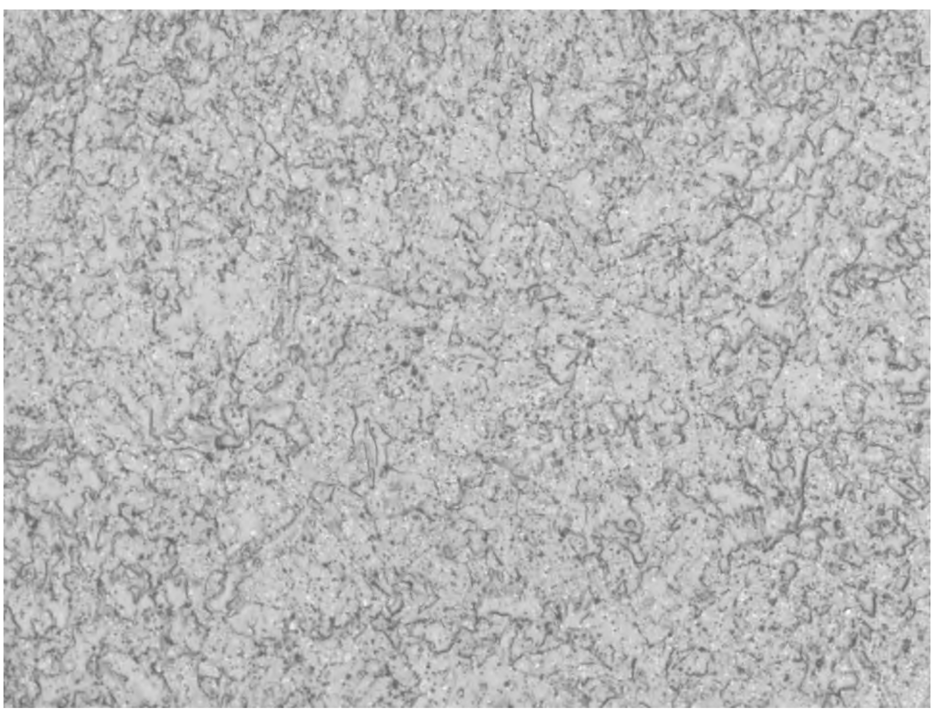

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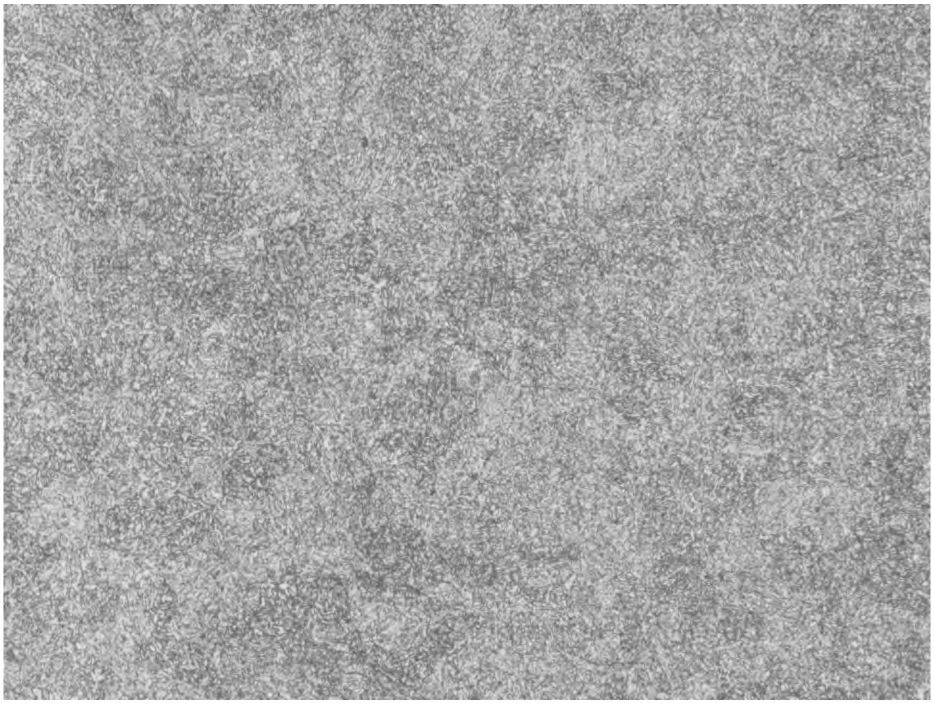
Fig. 26. Replica No. HRH-R4.

Fig. 27. Replica No. HRH-R5.



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Bainite and ferrite microstructure

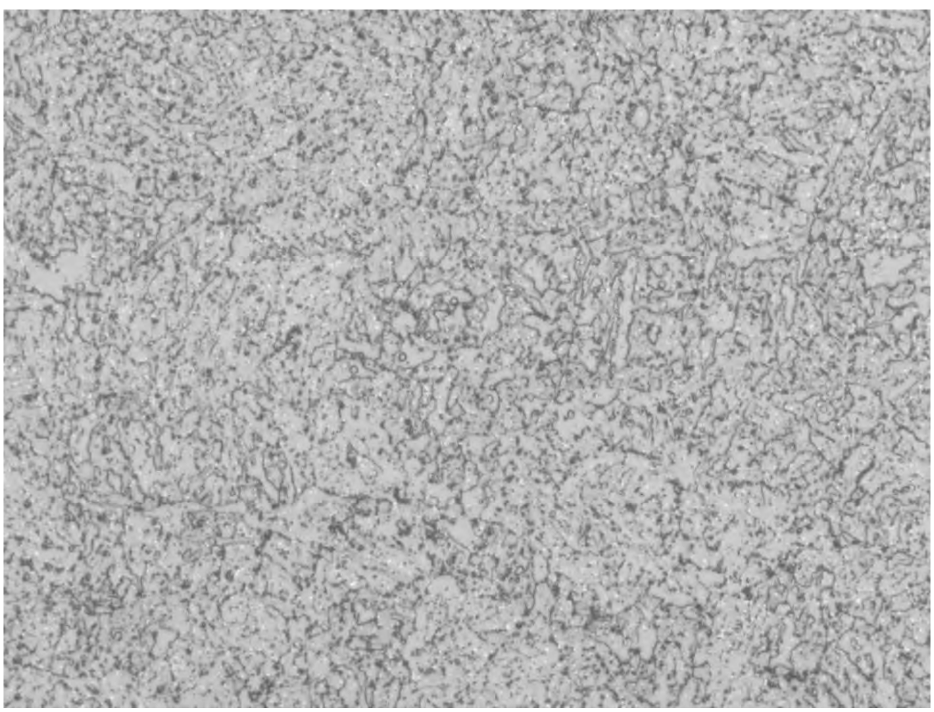

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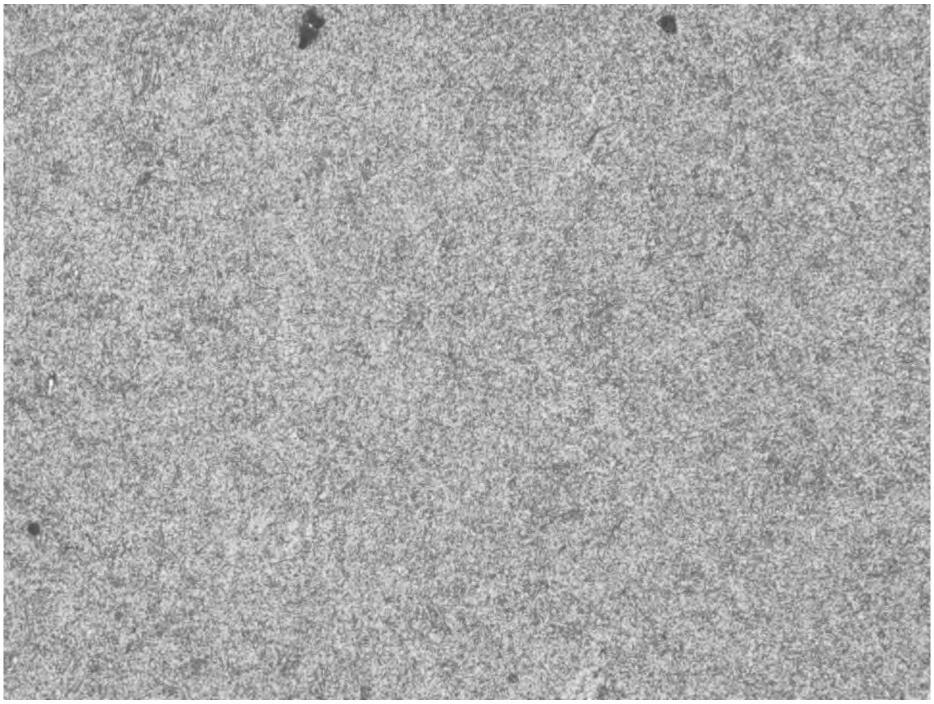
Fig. 27. Replica No. HRH-R5.



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Bainite and ferrite microstructure

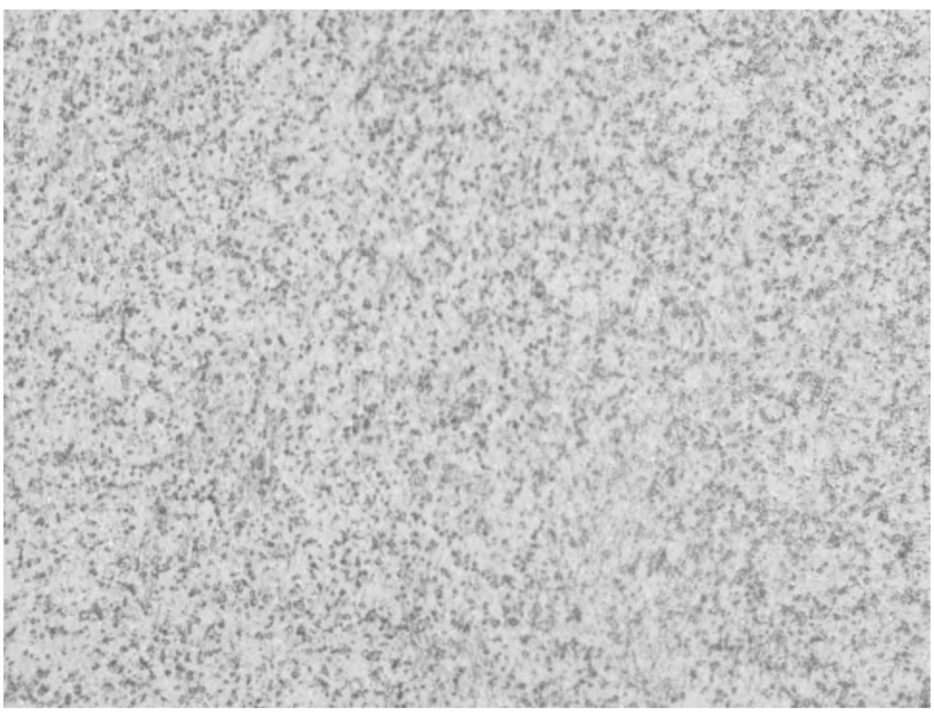

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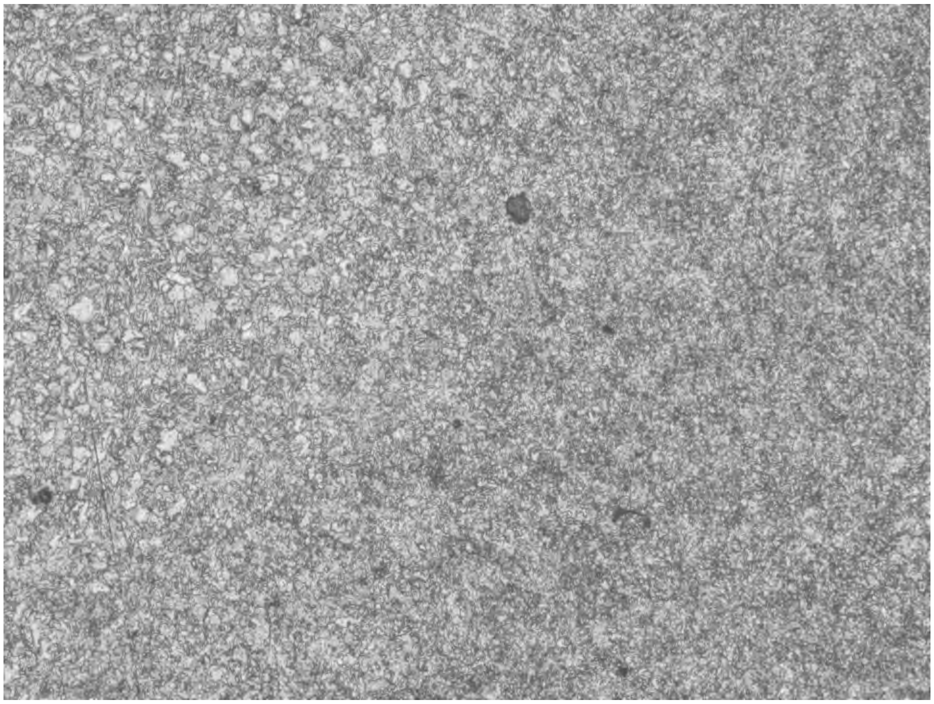
Fig. 28. Replica No. HRH-R6.



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Bainite and ferrite microstructure

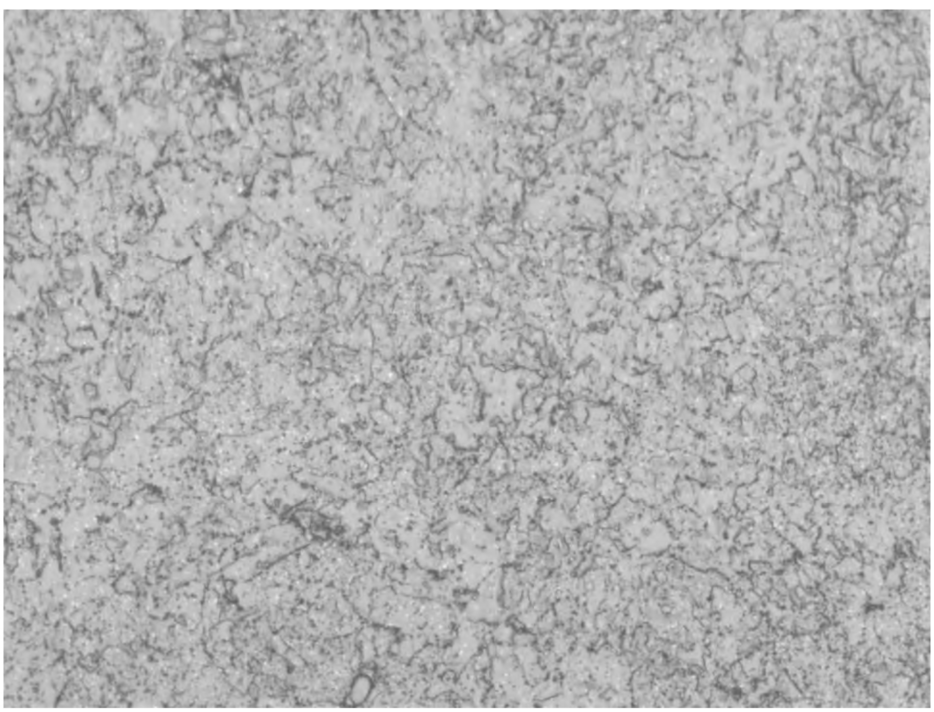

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Fig. 29. Replica No. HRH-R7.