IDEaS CDIS Sandbox

Visiooimage Inc.
Infrared Thermography NDT with Eddy Current/Induction Heating
Report version 2023-06-09 – Rev. G

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COVE, Darthmouth, May 9-13th, 2022
To IDEaS for the CDIS sandbox

by
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TABLE OF CONTENT

General considerations

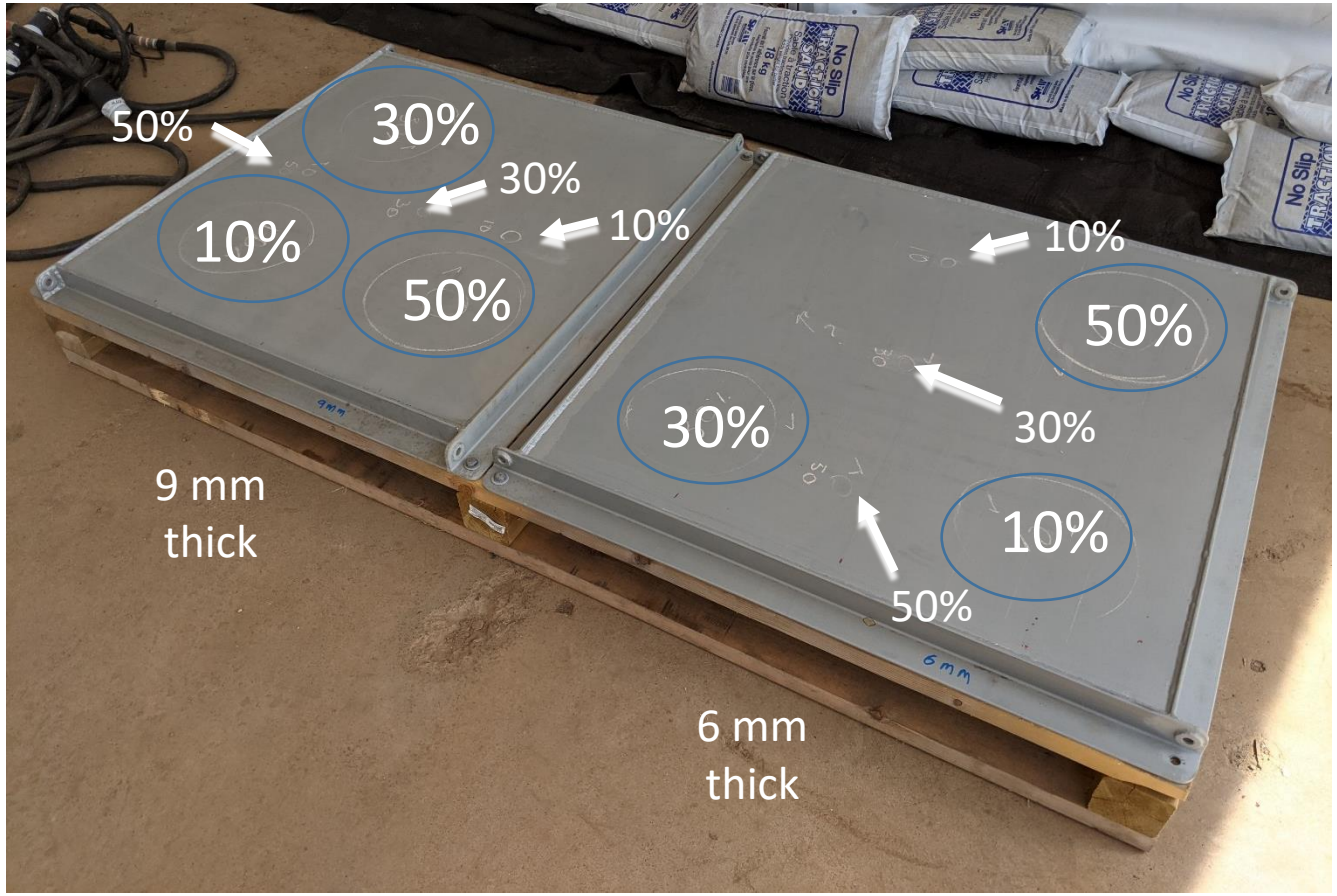
Unless indicated otherwise, all the images presented in this report are intentionally shown in their raw. They have not undergone any processing other than real-time adjustments of the classical Infrared color palette using Adaptive Plateau Equalization (APE). All heating was conducted manually without any guidance or surface preparation.

The inspection was carried out by two operators who are experienced seniors in Infrared Thermography (IRT) but have limited knowledge and experience specifically in corrosion detection, particularly in terms of determining the optimal power, speed, and ideal coil to be used. The operators' dexterity in moving the coil can be considered at a beginner level. Although a computer and a tripod-mounted camera were used for the inspection, it is worth noting that a handheld IR camera without a computer could have been utilized as well.

For the baseline parts (pipes and deck), the position of the defects was known at the time of producing this report. However, for all the other test parts (restricted deck, unrestricted deck, long mounted un-insulated red pipe, hull, ship hull #707), the position of the defects was unknown.

Please refer to the document titled "Visiooimage_Induction_Heating_Basics_IDEaS_CDIS_Sandbox_2022-04-05_cic" for further explanation regarding the principles discussed.

Baseline: general corrosion + pitting corrosion (100393)



Notes:

- Plates: 6 mm and 9 mm thick.

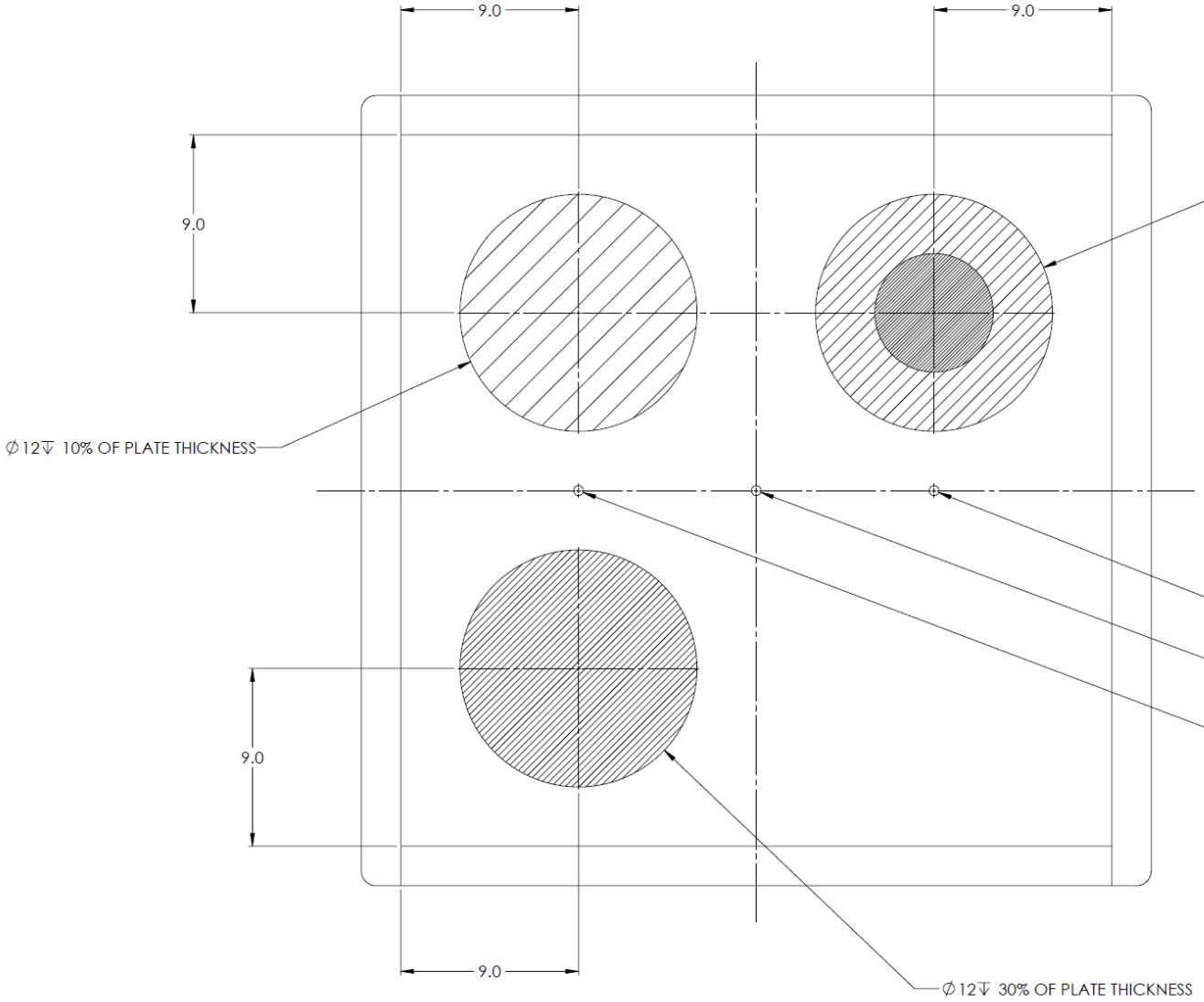
- Simulating general corrosion (large FBH) and pitting corrosion (small FBH).

- Percentage indicates thickness reduction.

- FBH located on the back side.

- Paint only, no coating.

Baseline: general corrosion + pitting corrosion (100393)



NOTE: SURFACE FEATURES TO BE GROUND INTO BOTTOM FACE AS CLOSE AS POSSIBLE TO TARGET DEPTH

↧ 50% OF PLATE THICKNESS (50% REMAINING)

↧ 30% OF PLATE THICKNESS (70% REMAINING)

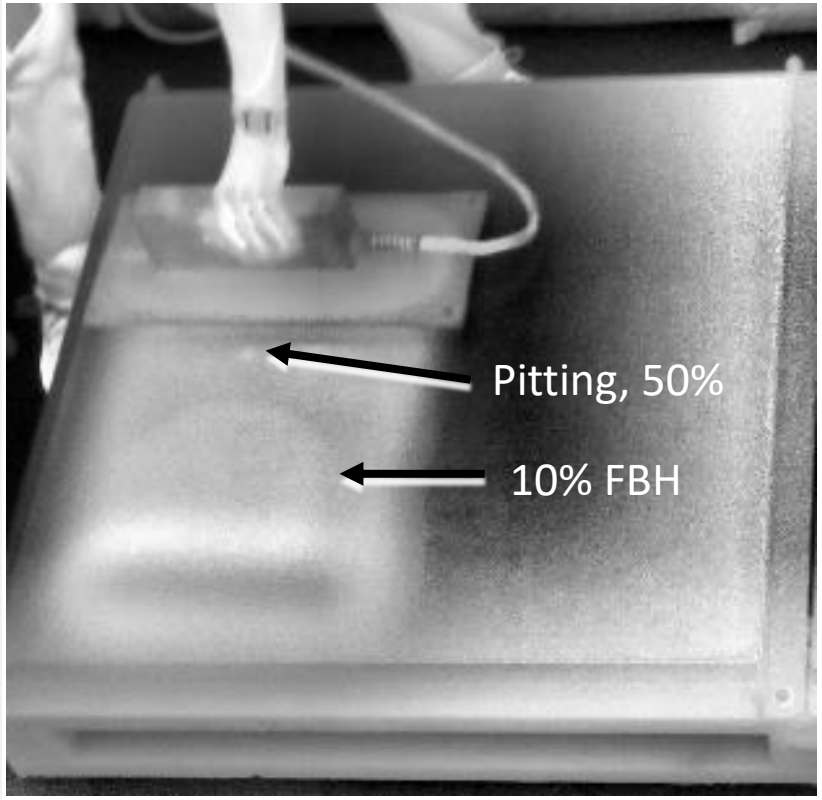
↧ 25% OF PLATE THICKNESS (75% REMAINING)

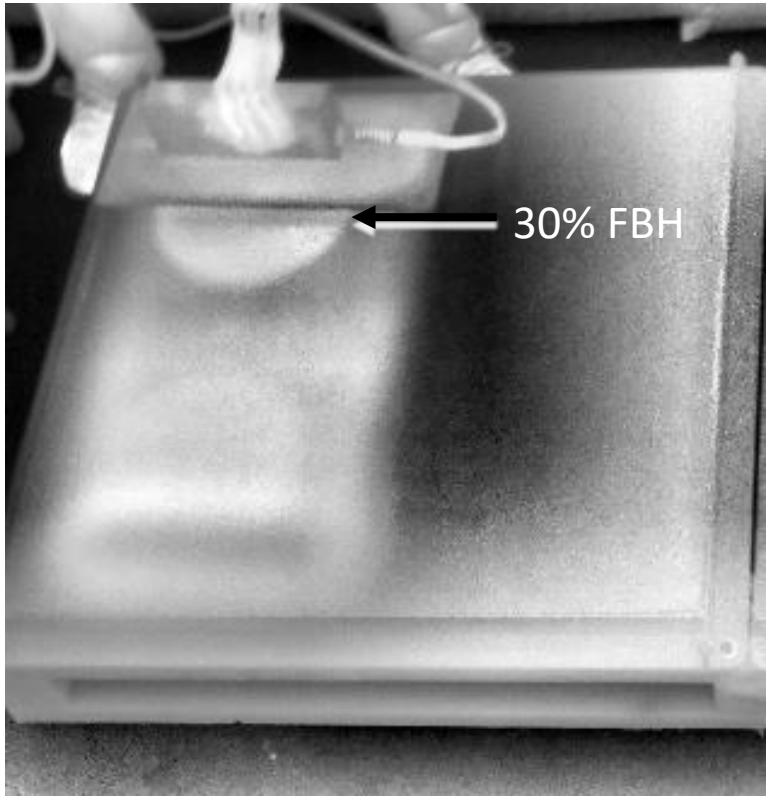
↧ 10% OF PLATE THICKNESS (90% REMAINING)

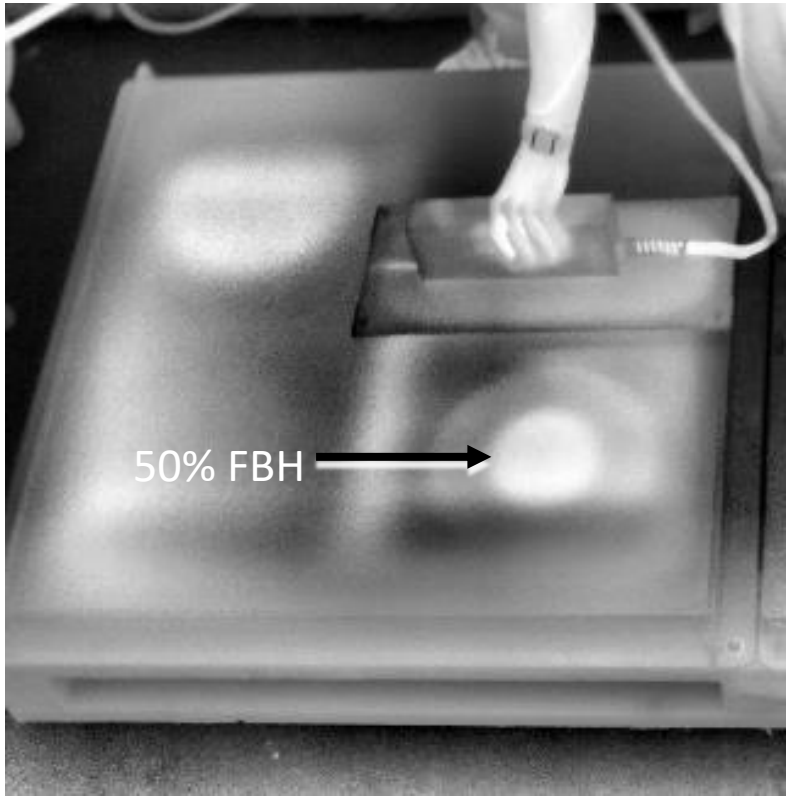
VARIATION TABLE	
DRAWING NUMBER	DESCRIPTION
100393-01	ITEM 1 - 6 mm PLATE
100393-02	ITEM 1 - 9 mm PLATE

MATERIAL: 2.0		FINISH: 3.0	
TASK NO: IT3746-S	NAVAL ENGINEERING TEST ESTABLISHMENT (NETE) HALIFAX, NOVA SCOTIA, CANADA		
DRAWN: M.LEGGE	TITLE: CALIBRATION PANEL TESTBED		
APPROVED:			
MFG.	SIZE D	DWG. NO. 100393	REV 1
Q.A.			
ENG. A. SAULNIER	SCALE: 1:5	WEIGHT: 166.21 LBS	SHEET 2 OF 2

Baseline: general + pitting corrosion **9 mm** plate



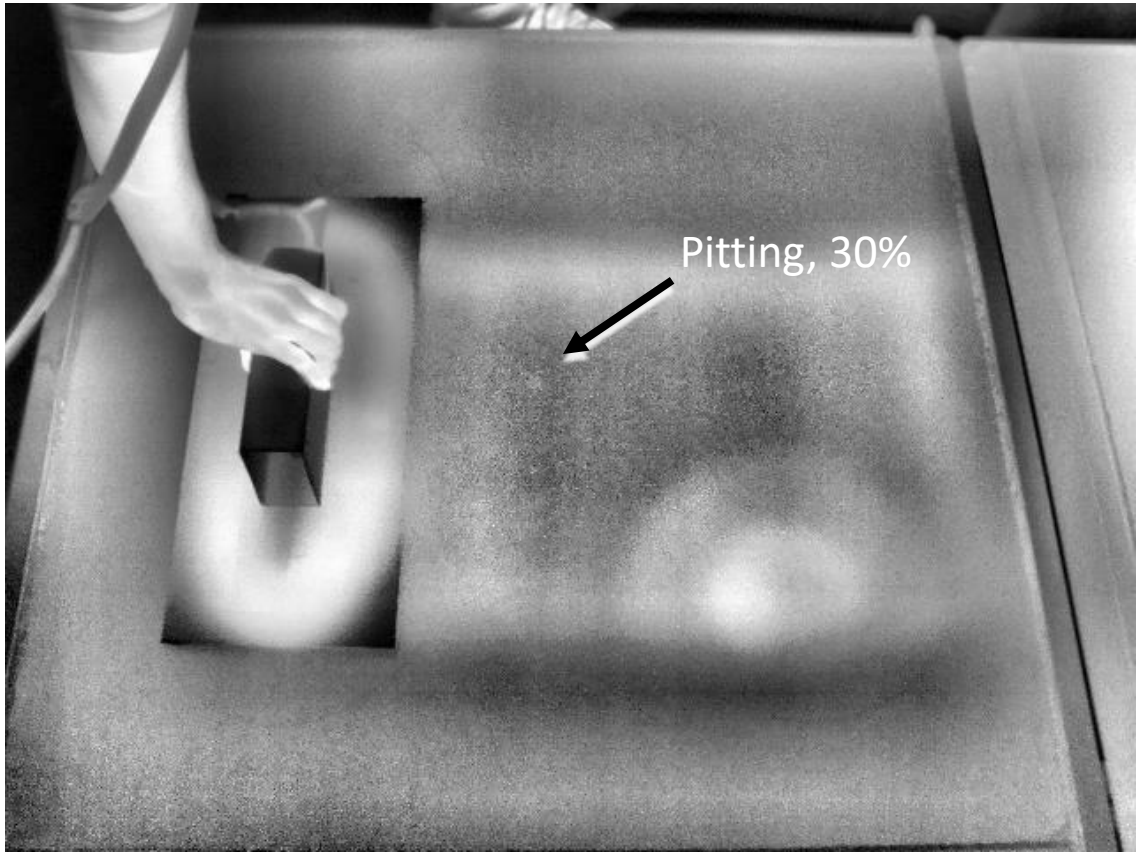


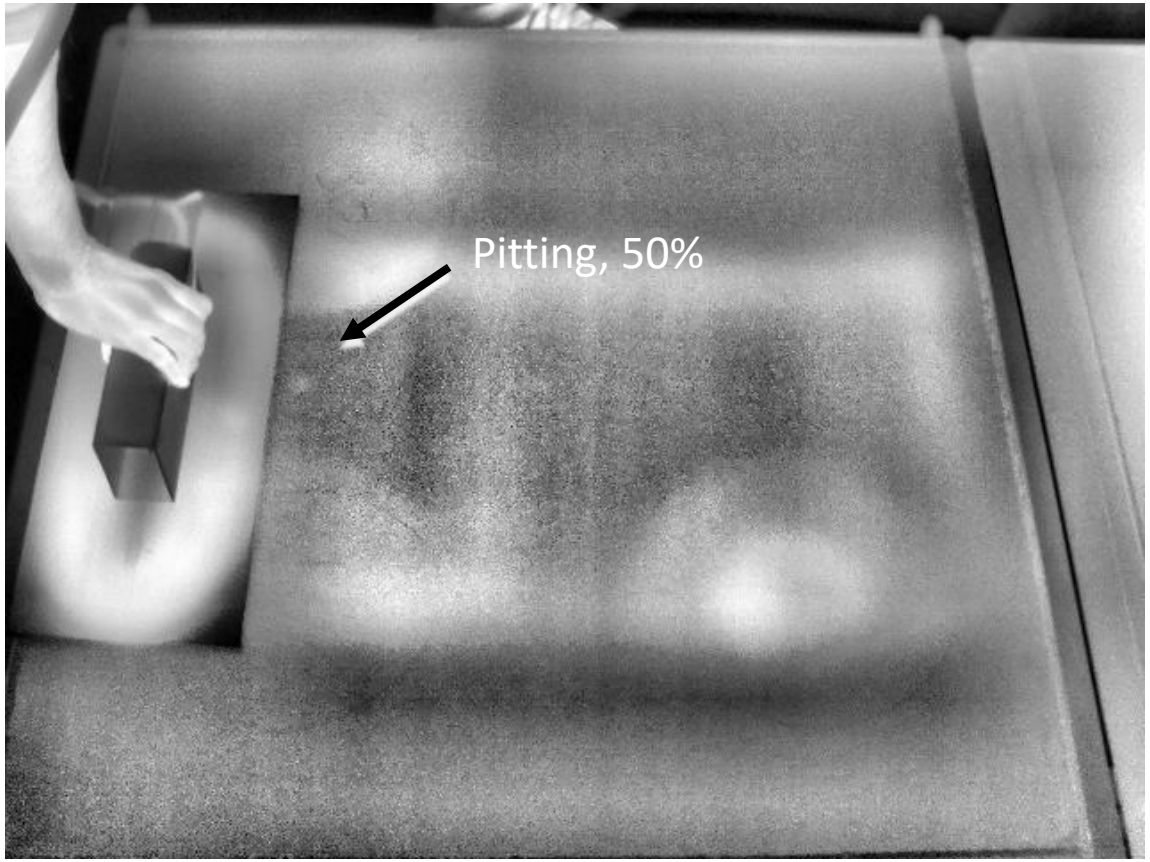


Notes:

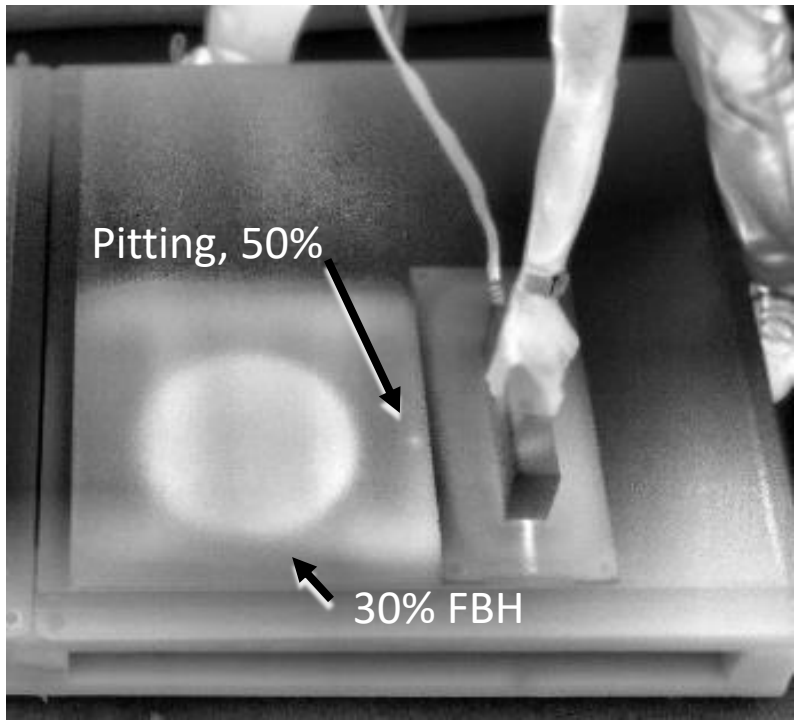
- Defects that vanish quickly are better observed in video or real-time rather than still images.
- Inspection speed can be determined by comparing video length (time) to the length (size) of the test part.

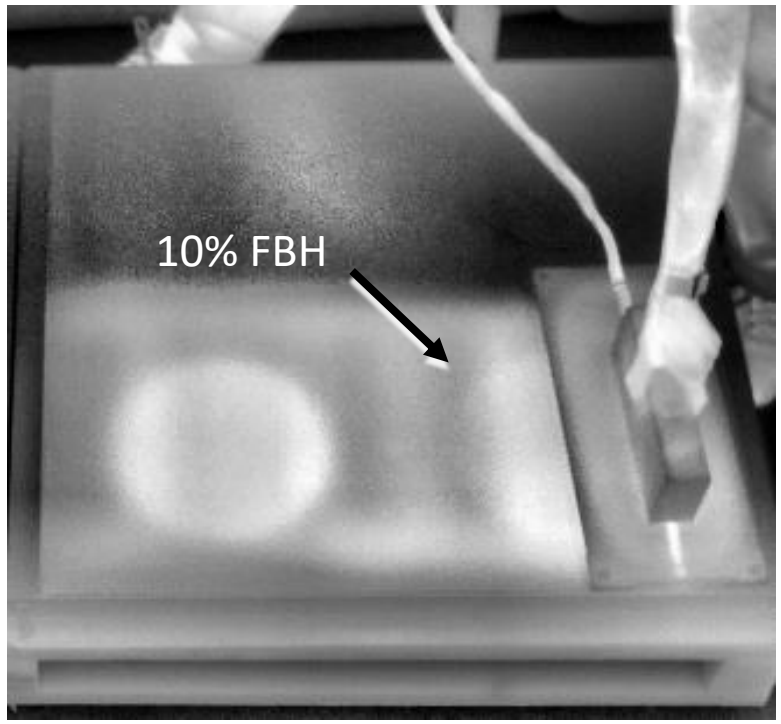
Baseline: general + pitting corrosion **9 mm** plate

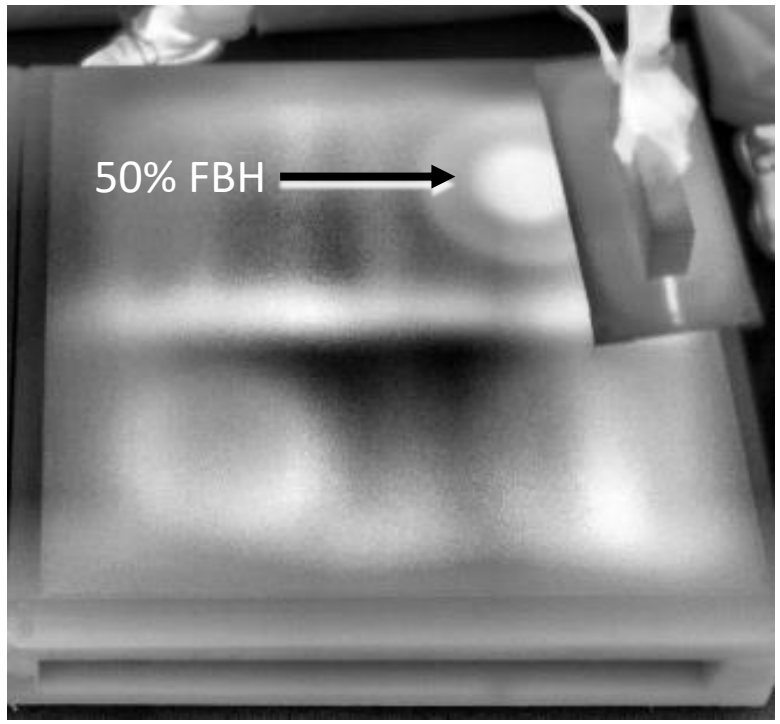




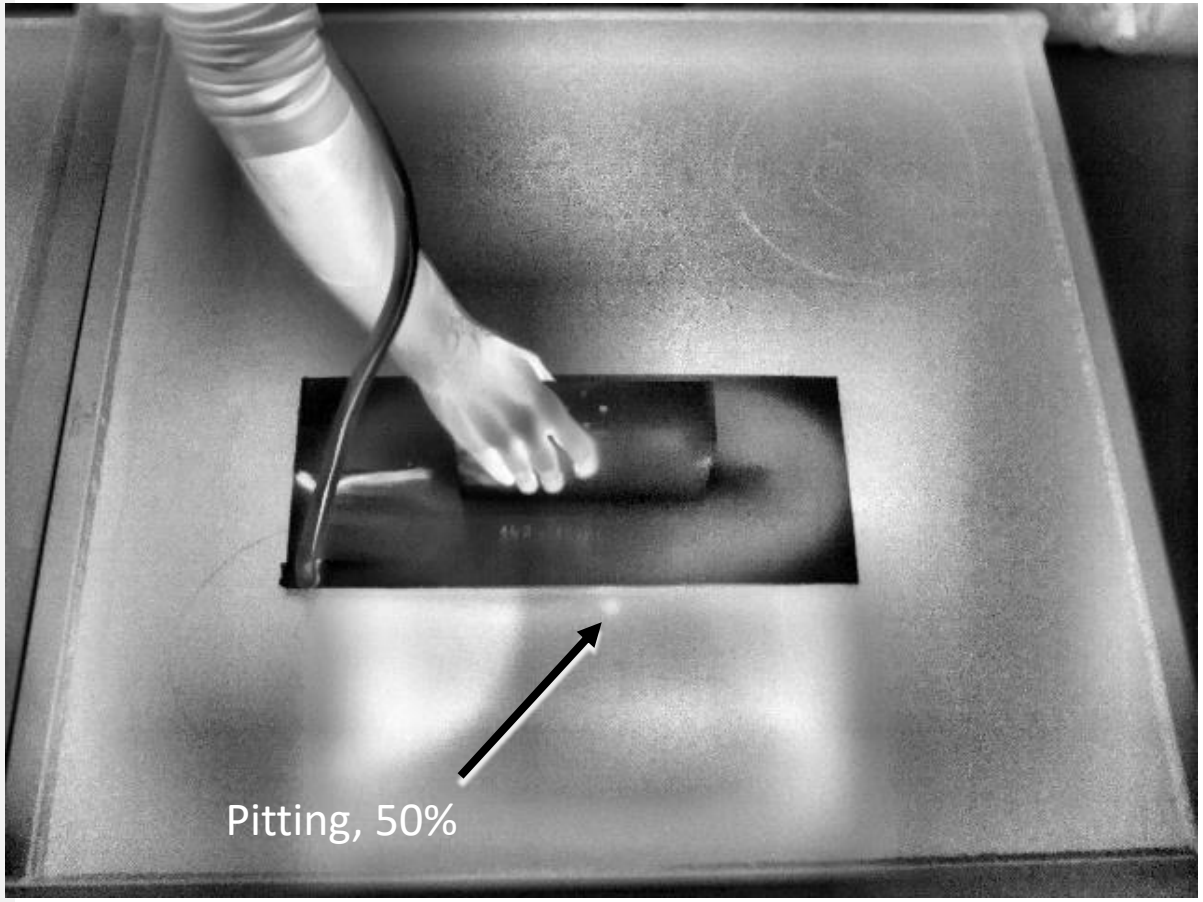
Baseline: general + pitting corrosion **6 mm** plate



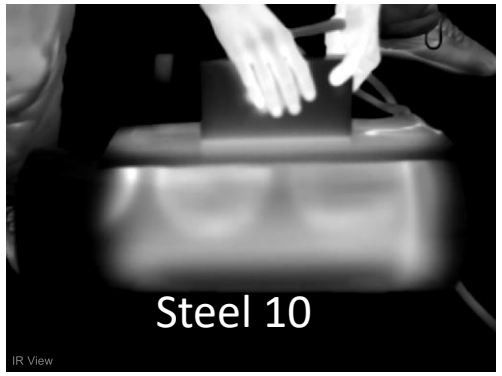


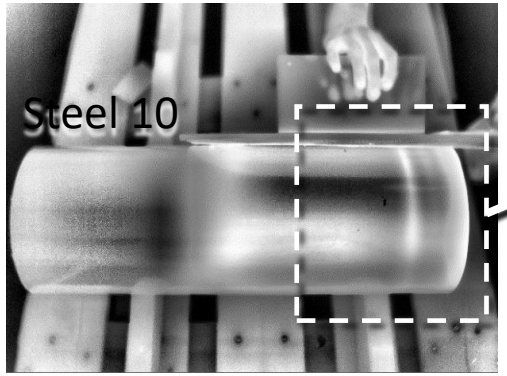


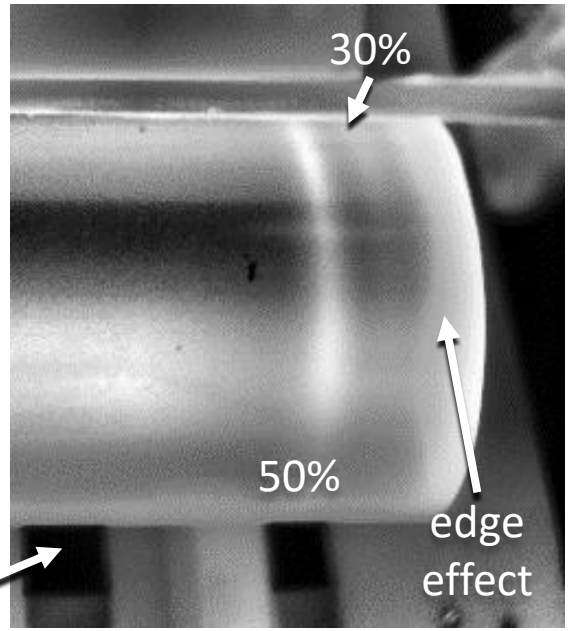
Baseline: general + pitting corrosion **6 mm** plate

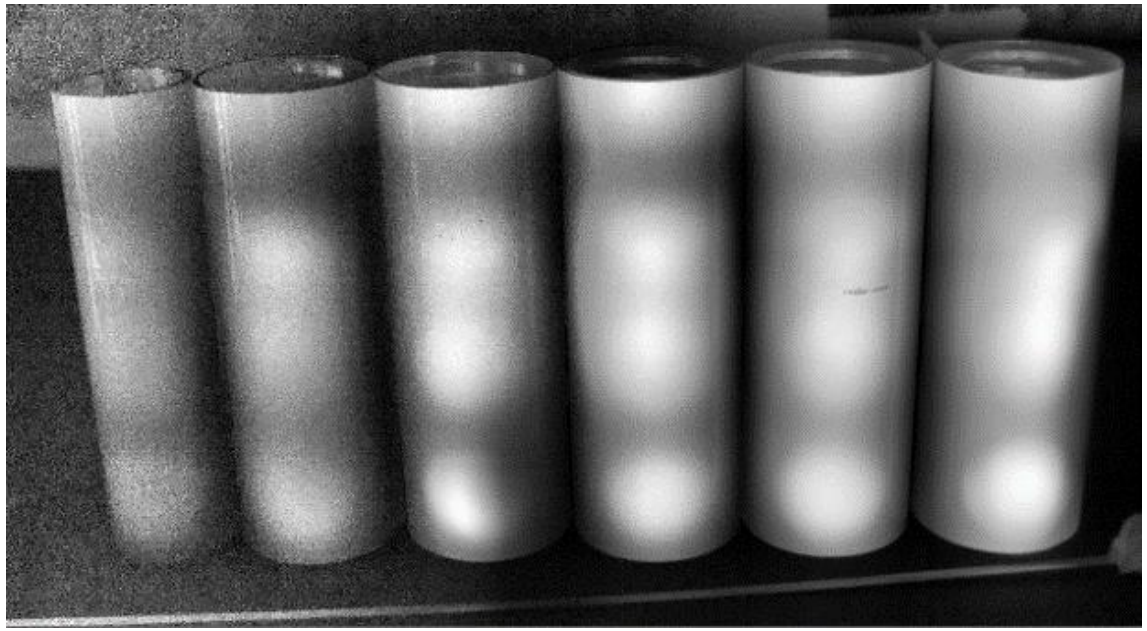


Baseline Pipes: general and pitting corrosion (100394)



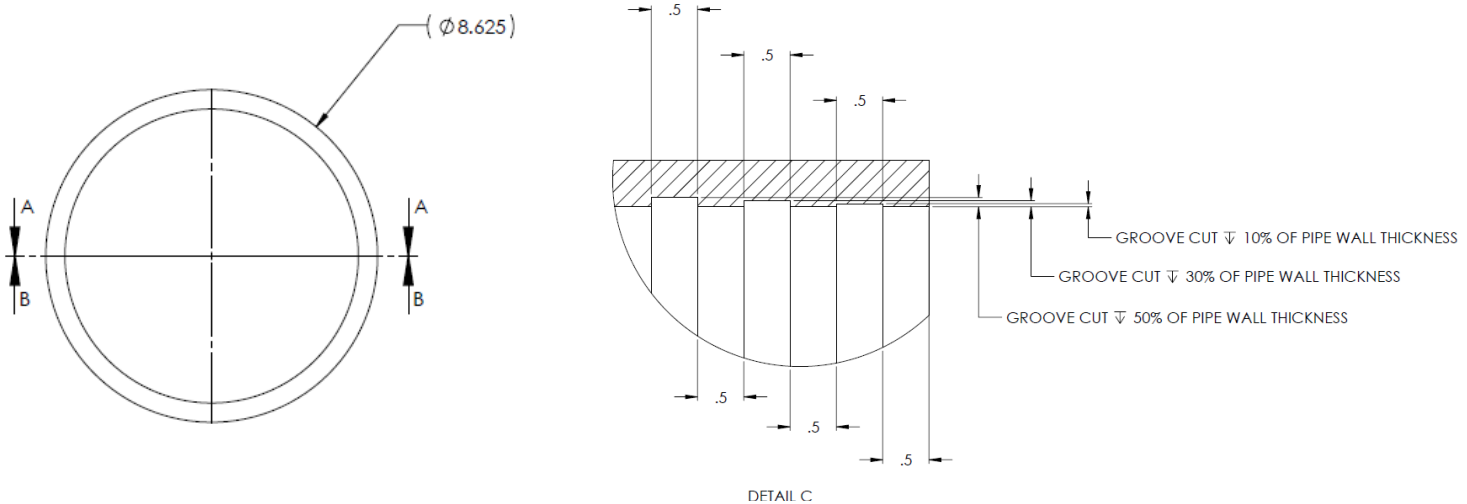




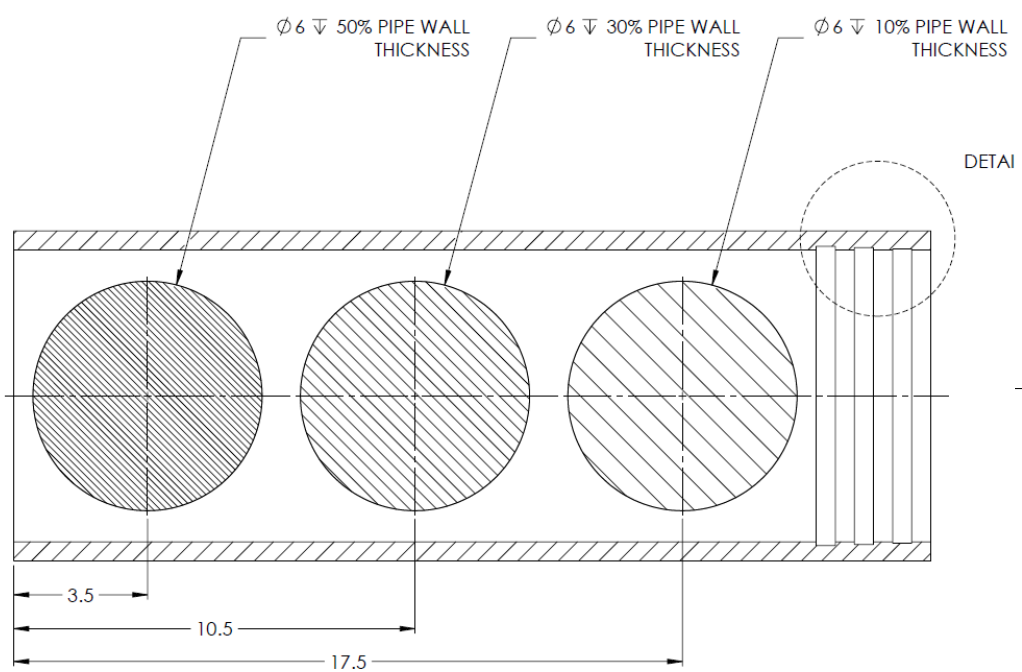


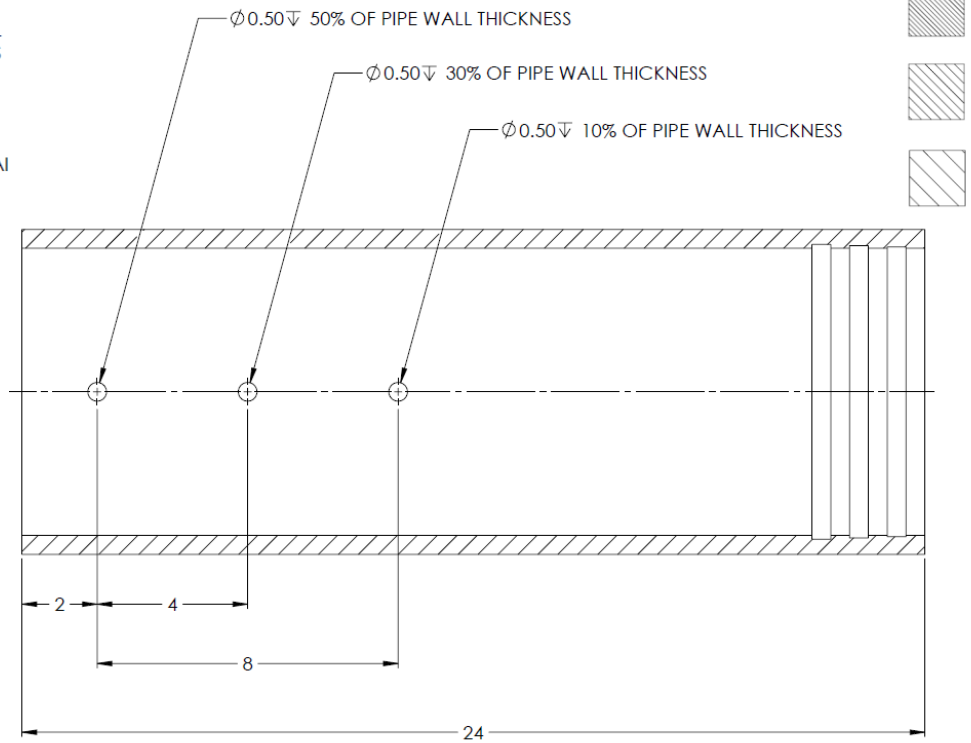
Baseline Pipes: general and pitting corrosion (100394)

VARIATION TABLE		
PART NUMBER	3.0 PIPE SCHEDULE	2.0 MATERIAL
100394-01A	10	CARBON STEEL
100394-01B	10	90/10 CuNi
100394-02A	40	CARBON STEEL
100394-02B	40	90/10 CuNi
100394-03A	80	CARBON STEEL
100394-03B	80	90/10 CuNi



MATERIAL: 2.0	FINISH: 4.0
TASK NO: IT3746-S	NAVAL ENGINEERING TEST ESTABLISHMENT (NETE) HALIFAX, NOVA SCOTIA, CANADA
DRAWN: M. LEGGE	TITLE: PIPING SAMPLE
APPROVED:	
MFG.	SIZE D / DWG. NO. 100394 / REV 1
Q.A.	
ENG. A. SAULNIER	SCALE: 1:5 / WEIGHT: 10.66 LBS / SHEET 1 OF 1





NOTE: SURFACE FEATURES TO BE GROUND INTO INSIDE PIPE FACE AS CLOSE AS POSSIBLE TO TARGET DEPTH

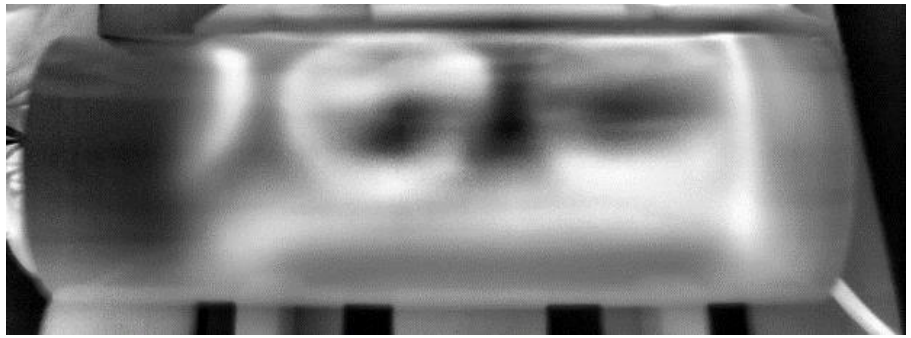
↧ 50% OF PIPE WALL THICKNESS (50% REMAINING)

↧ 30% OF PIPE WALL THICKNESS (70% REMAINING)

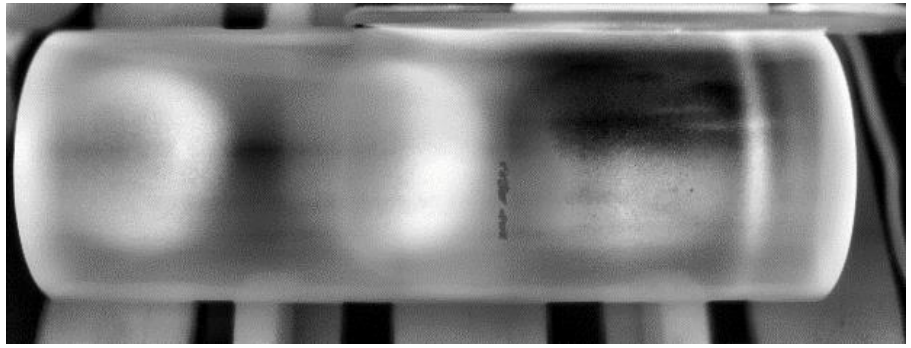
↧ 10% OF PIPE WALL THICKNESS (90% REMAINING)

Baseline Pipes: steel

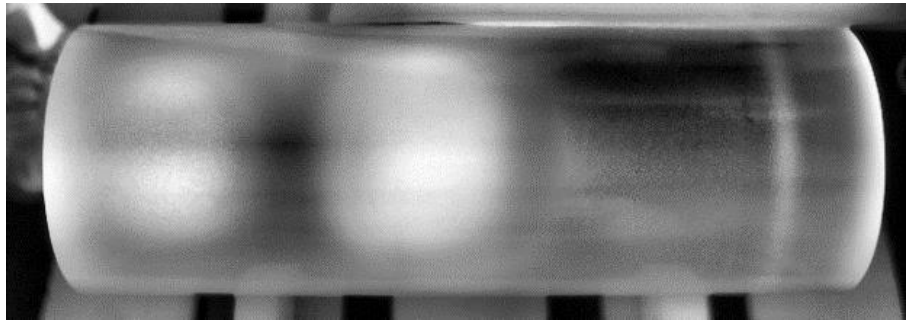
Steel 10



Steel 40



Steel 80

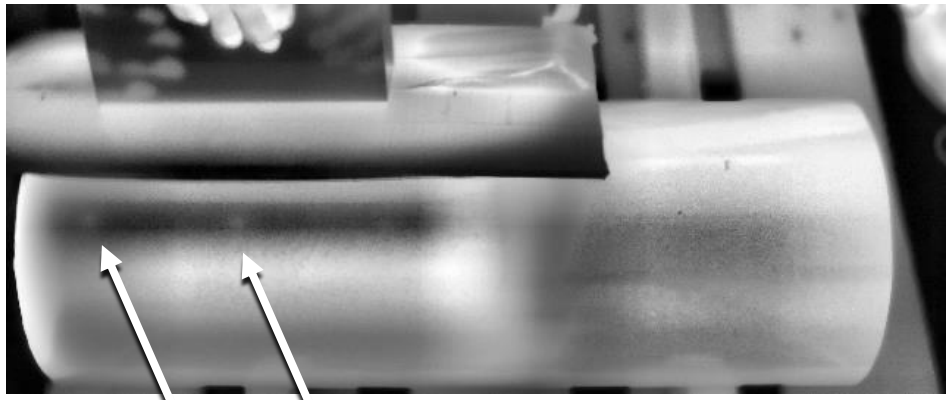


Notes:

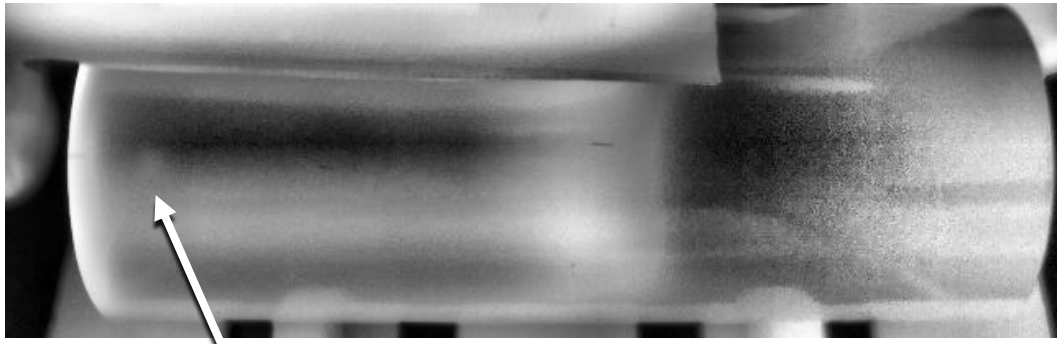
- A rectangular flat coil is not well-suited for pipes. A smaller or curved coil may potentially yield better results.

Baseline Pipes: steel, pitting

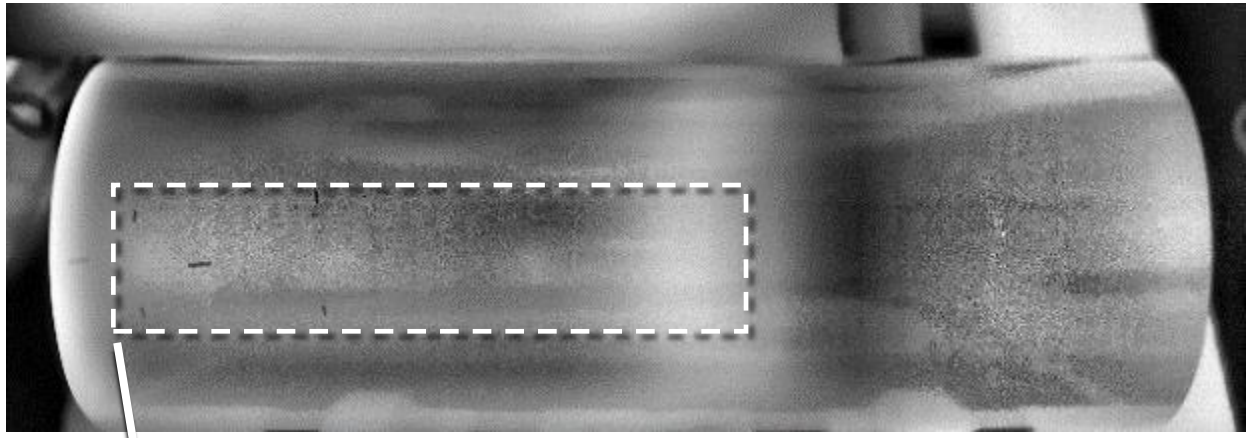
Steel 10



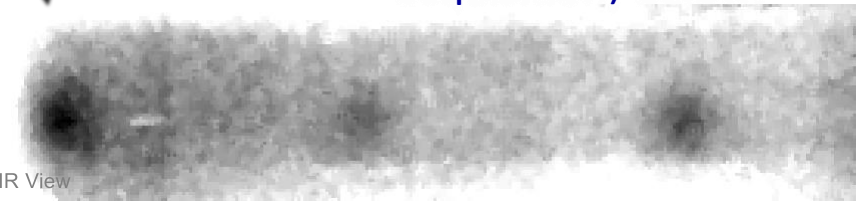
Steel 40



Steel 80



Pitting corrosion in the 80 steel is not visible. However, with minimal time processing using a computer, the pitting can be easily detected. An example is shown below using processing type PCT EOF3 and 200 frames, clearly revealing all the simulated pitting corrosion in the 80 steel (same acquisition) below:



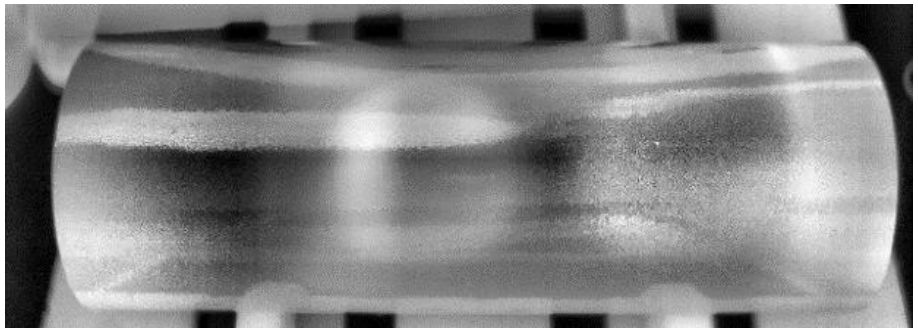
Notes:

- A rectangular flat coil is not well-suited for pipes. A smaller or curved coil may potentially yield better results.

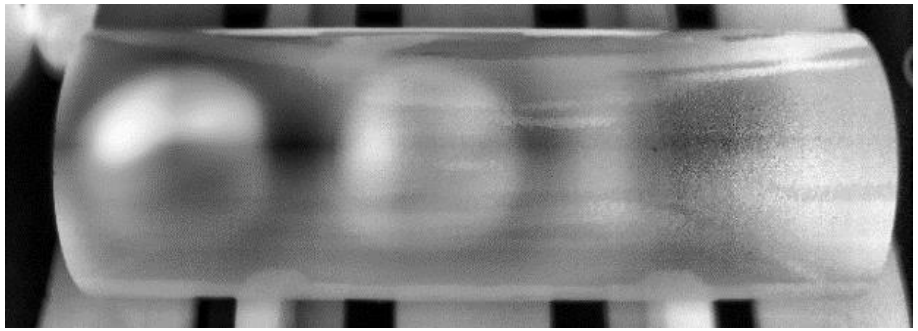
Baseline Pipes: Ni-Cu

Ni-Cu 10

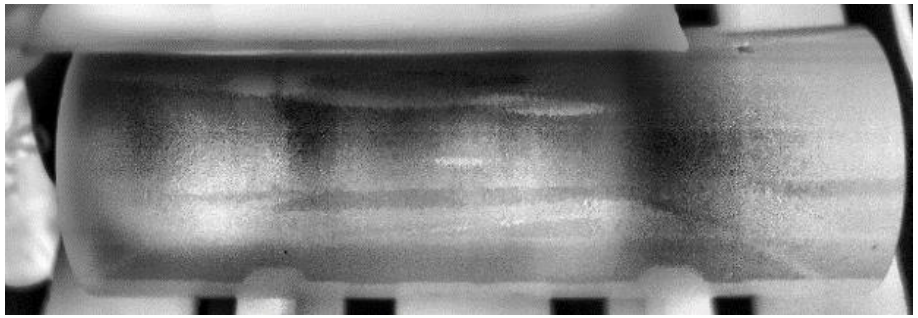
first scan

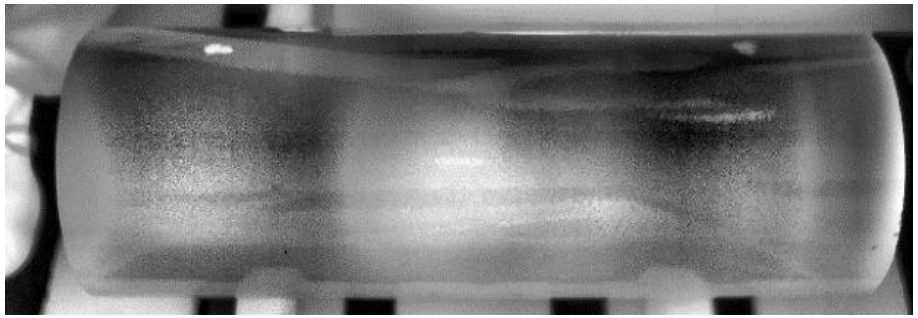


second scan

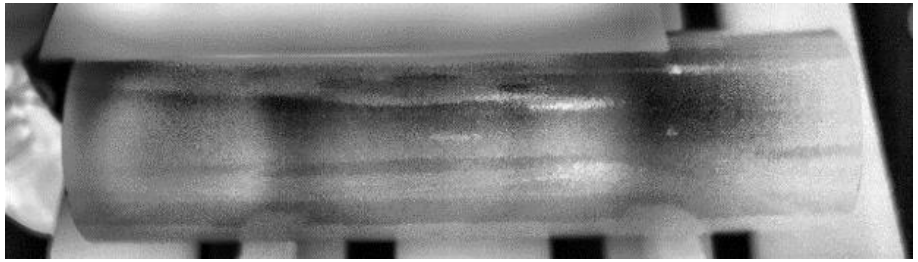


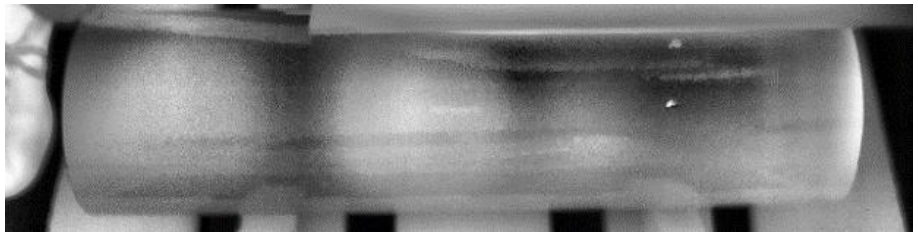
Ni-Cu 40



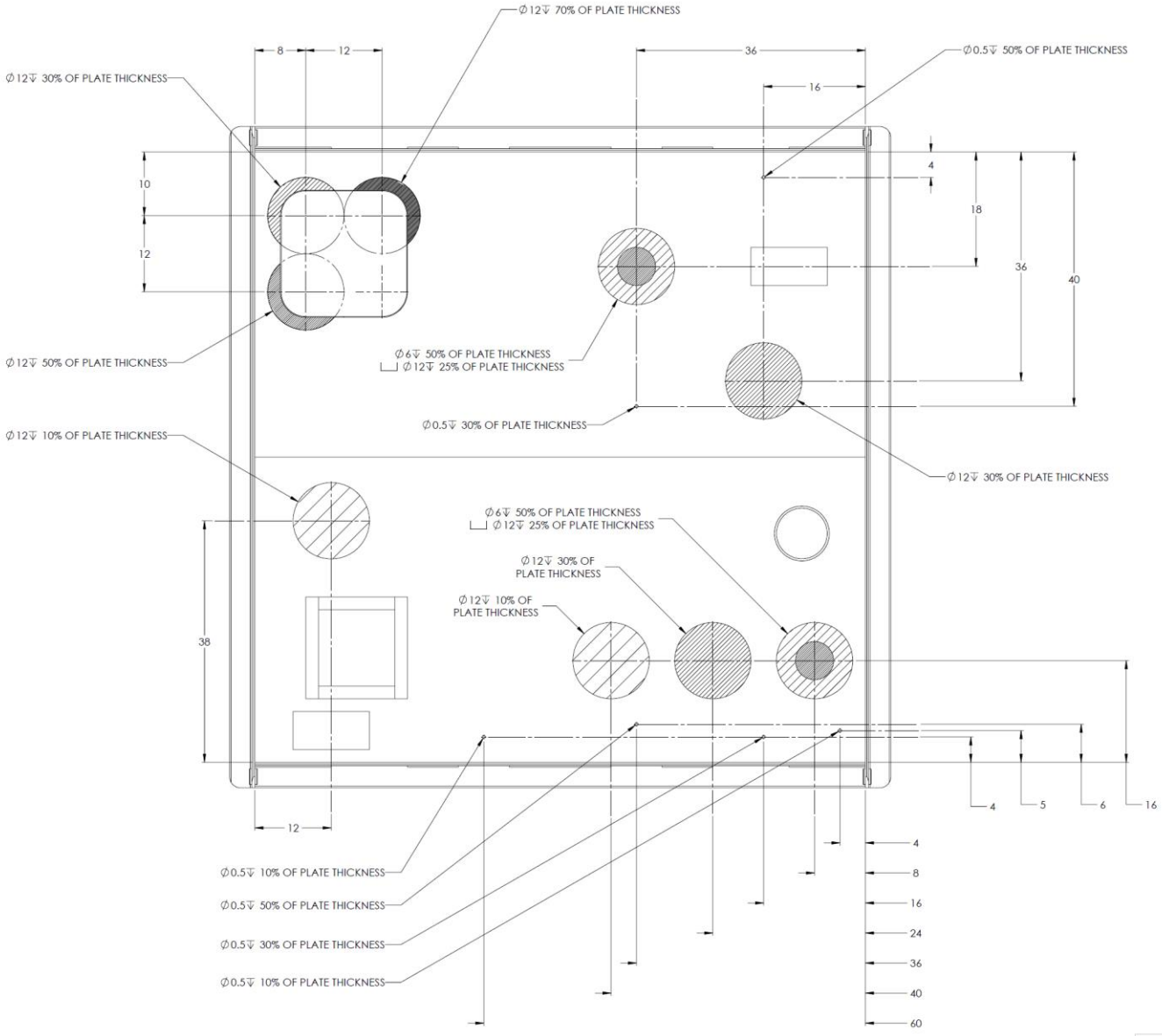


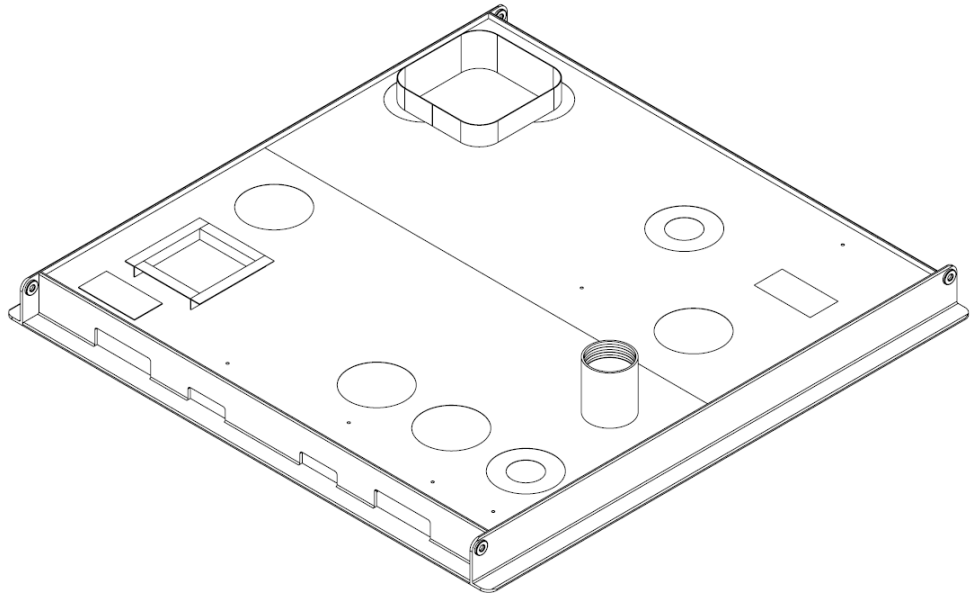
Ni-Cu 80





Unrestricted deck (100395)

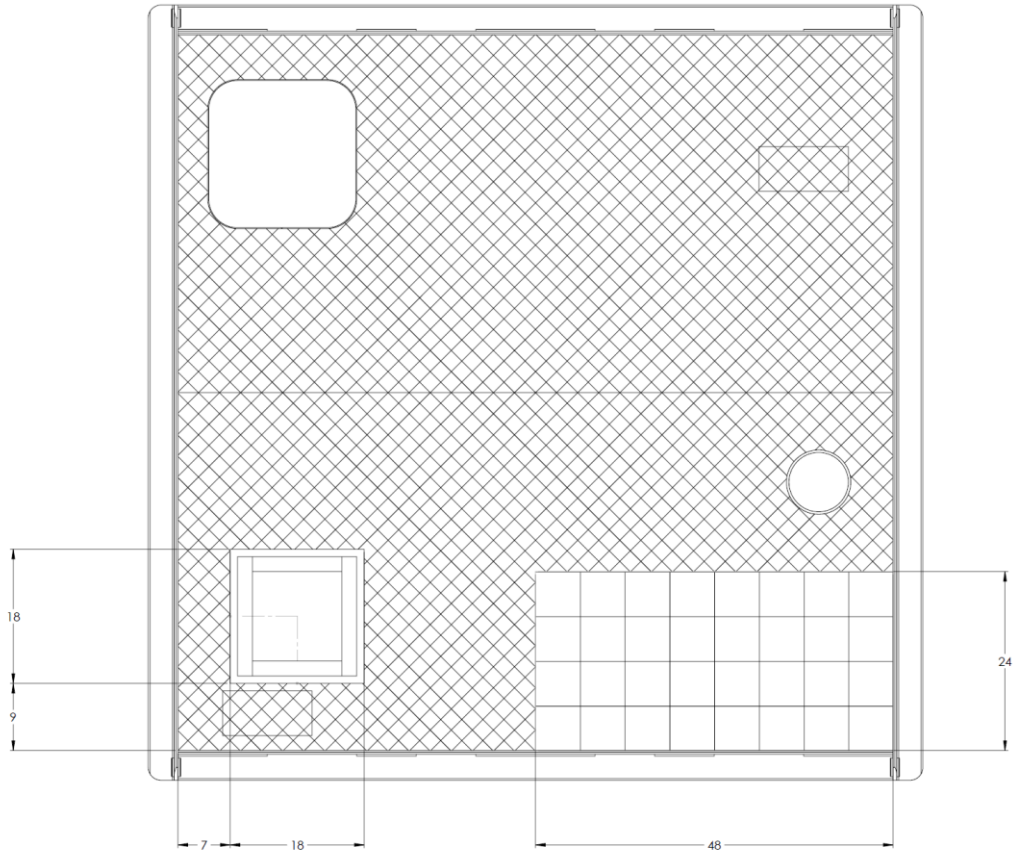


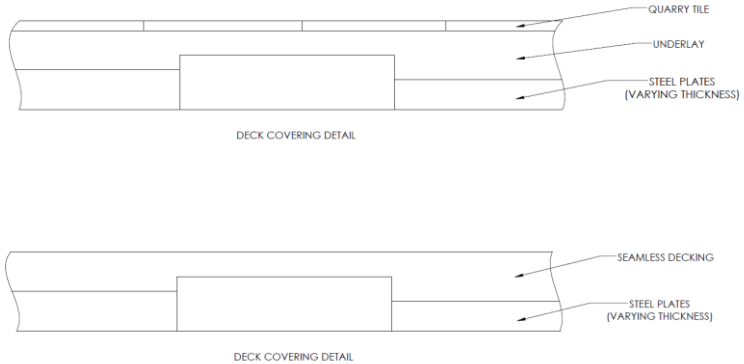


NOTE: SURFACE FEATURES TO BE GROUND INTO TOP FACE AS CLOSE AS POSSIBLE TO TARGET DEPTH

- ↧ 70% OF PLATE THICKNESS (30% REMAINING)
- ↧ 50% OF PLATE THICKNESS (50% REMAINING)
- ↧ 30% OF PLATE THICKNESS (70% REMAINING)
- ↧ 25% OF PLATE THICKNESS (75% REMAINING)
- ↧ 10% OF PLATE THICKNESS (90% REMAINING)

Unrestricted deck (100395)





QUARRY TILE DECKING

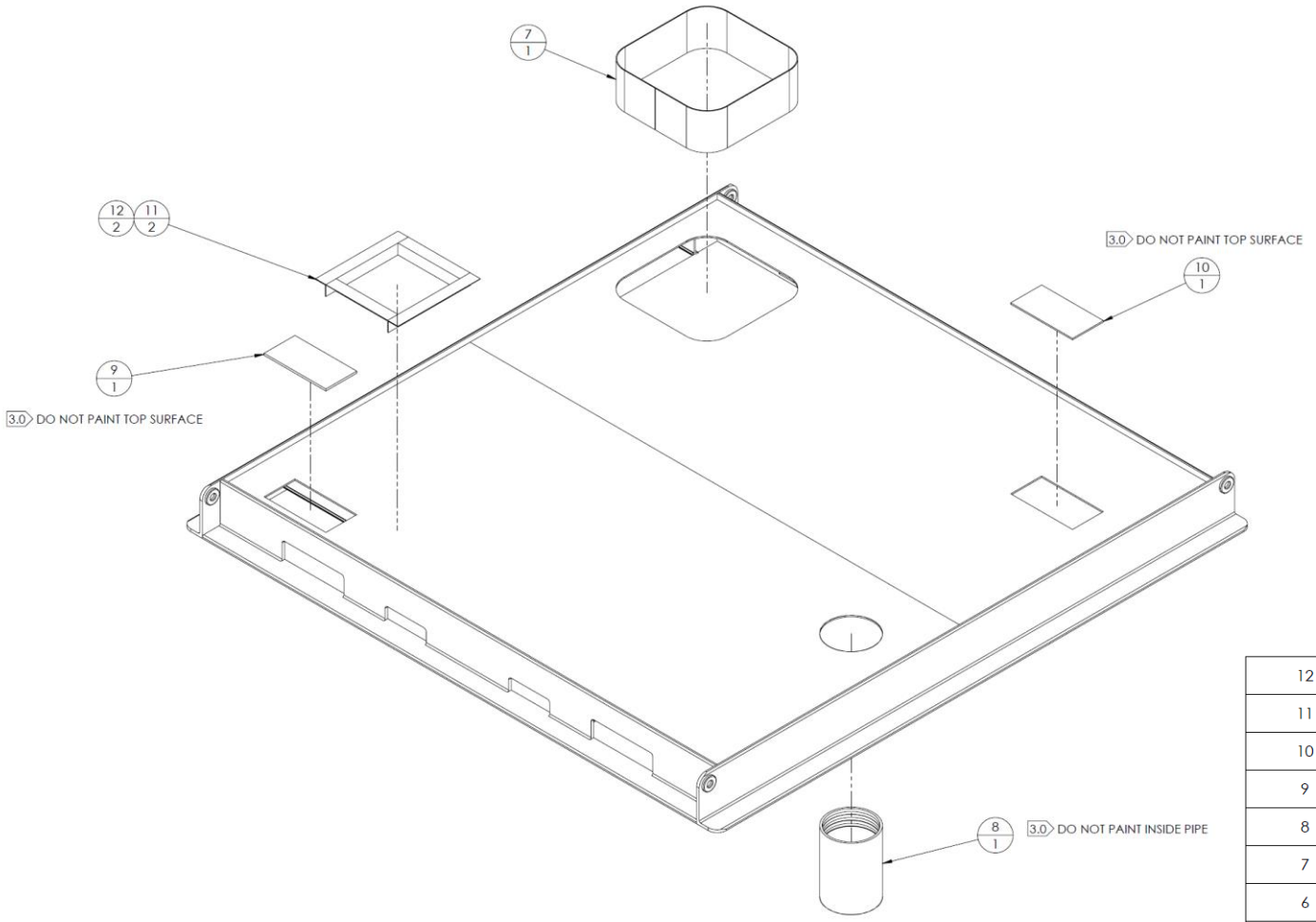
SEAMLESS DECKING

NO COVERING - PRIMED STEEL

NOTE: DECK COVERINGS TO BE INSTALLED AS PER HALIFAX CLASS FRIGATE SPECIFICATIONS

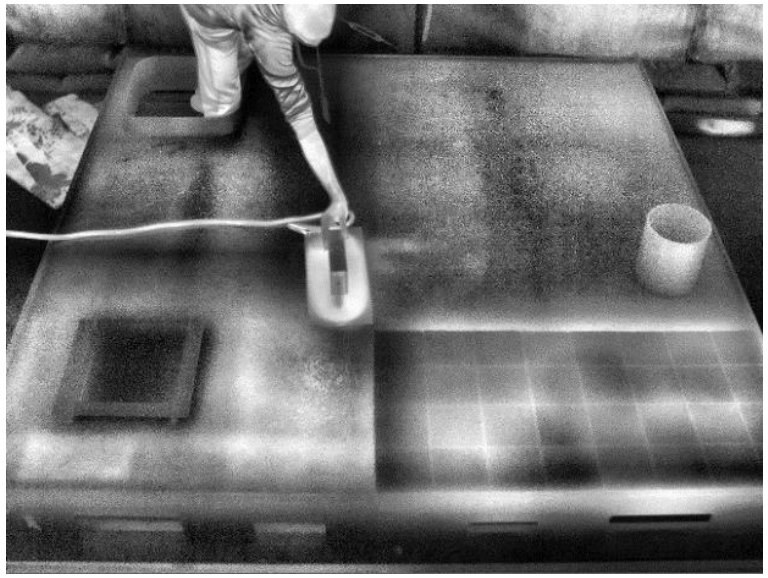
MATERIAL: 2.0		FINISH: 3.0	
TASK NO: IT3746-S	NAVAL ENGINEERING TEST ESTABLISHMENT (NETE) HALIFAX, NOVA SCOTIA, CANADA		
DRAWN: M.LEGGE	TITLE: DECK PLATING TESTBED		
APPROVED:			
MFG.	SIZE D	DWG. NO. 100395	REV 1
Q.A.			
ENG. A. SAULNIER	SCALE: 1:10	WEIGHT: 1459.29 LBS	SHEET 6 OF 6

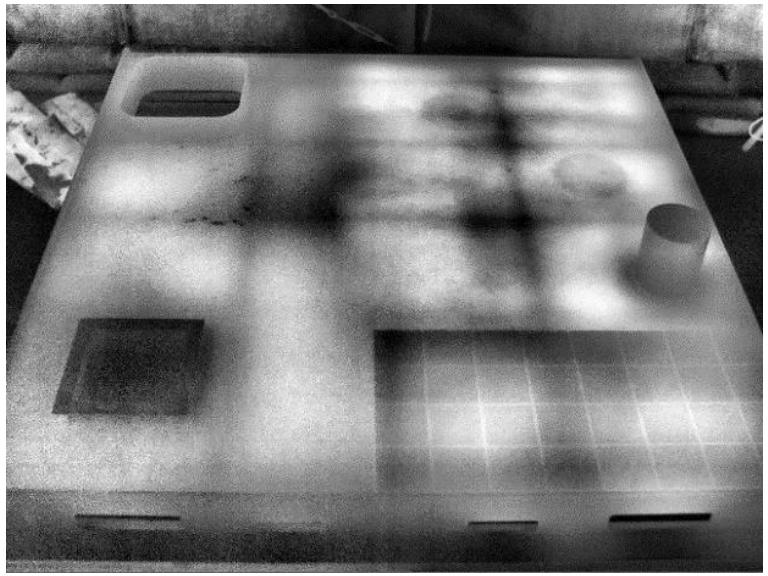
Unrestricted deck (100395)

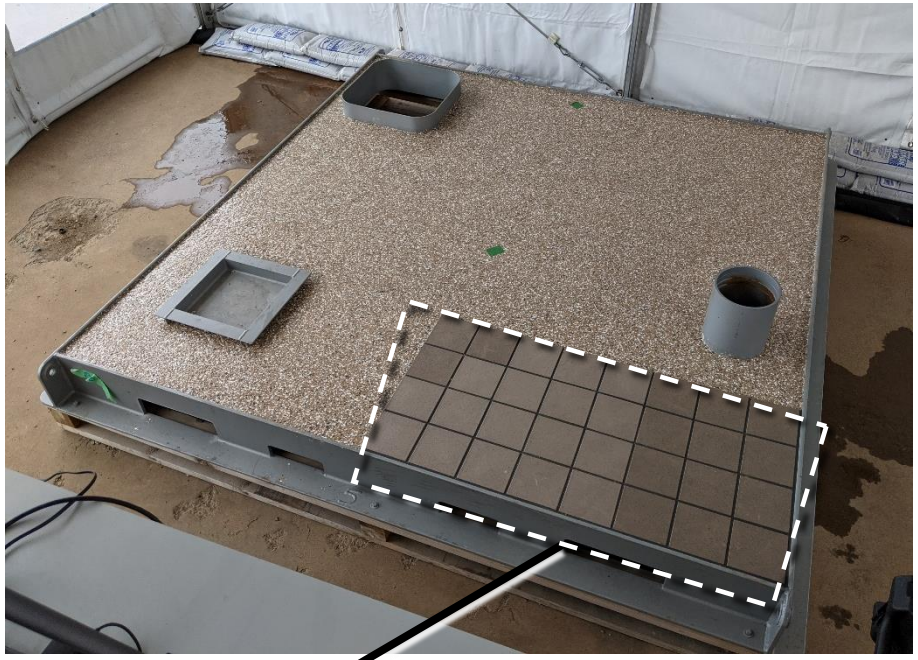


ITEM NO.	PART	DESCRIPTION	CUT LENGTH	QTY
12	FOUNDATION EDGE - SHORT	ANGLE BAR, STEEL,	12"	2
11	FOUNDATION EDGE - LONG	ANGLE BAR, STEEL,	16"	2
10	INSERT PLATE	PLATE, STEEL, 6mm	12" x 6"	1
9	INSERT PLATE	PLATE, STEEL, 9mm	12" x 6"	1
8	PIPE	PIPE, STEEL, 8" DIA, SCH. 40	12"	1
7	HATCH PLATE	PLATE, STEEL, 7" WIDTH, 0.1875" THK	CUT TO FIT	1
6	EYELET REINFORCEMENT	BAR, STEEL, 2.5" DIA, 0.375" THK	N/A	8
5	BEAM	T BAR, STEEL, 6" x 4" x 0.25"	96"	2
4	STIFFENER	T BAR, STEEL, 2.5" x 1" x 0.1875"	96"	5
3	FRAME EDGE - SHORT	ANGLE BAR, STEEL, 8" x 4" x 0.5"	96"	2
2	FRAME EDGE - LONG	ANGLE BAR, STEEL, 8" x 4" x 0.5"	104"	2
1	DECK PLATE	PLATE, STEEL, 6mm THK	96" X 48"	2

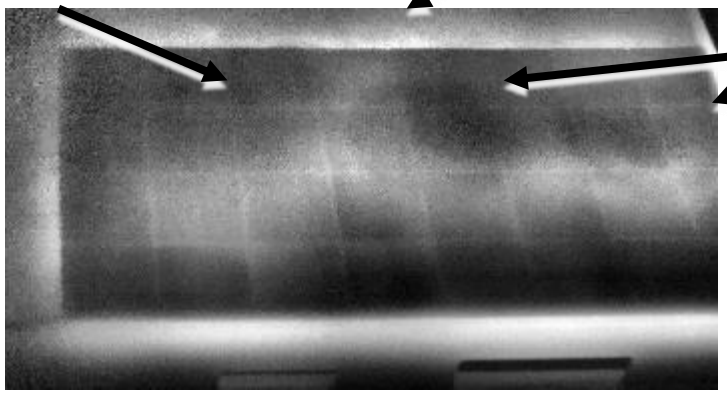
Unrestricted deck (100395)





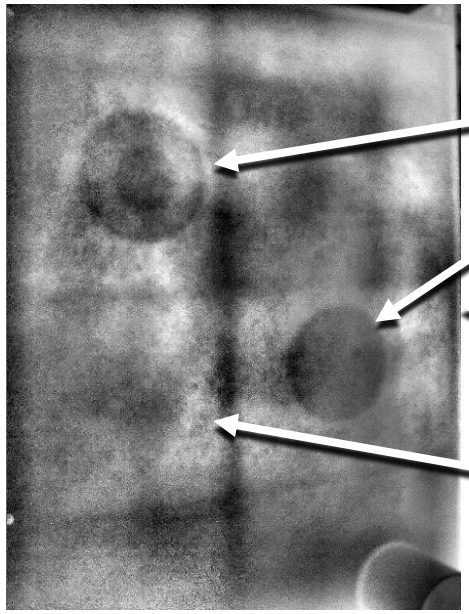


Suspected area



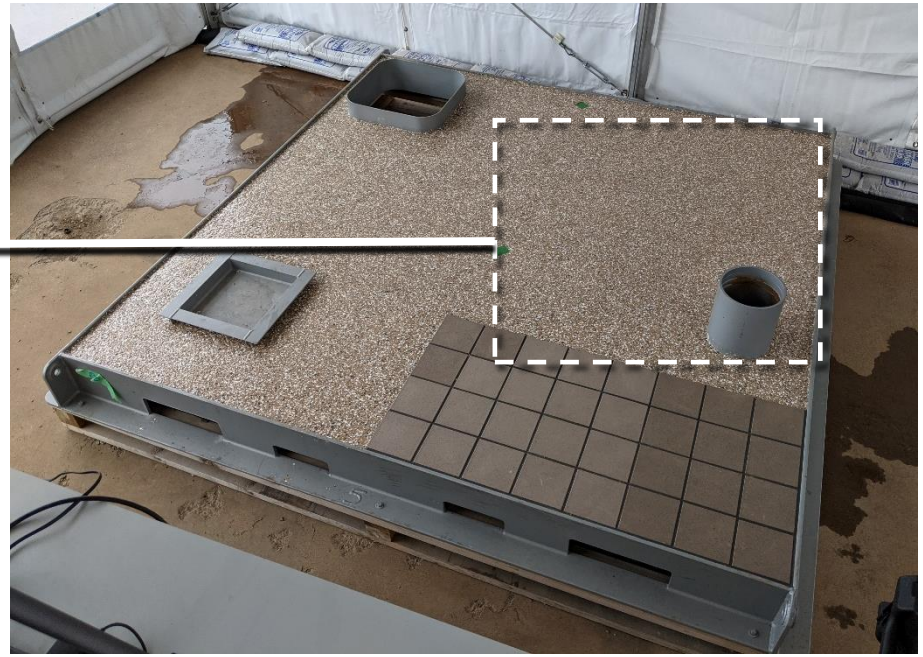
2 circles. The one on the right has a double step

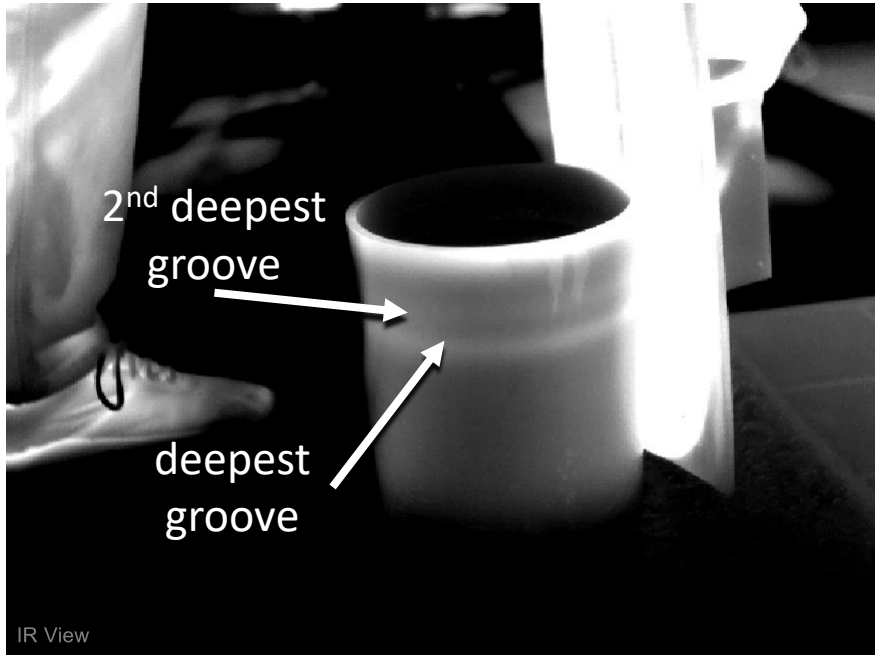
Unrestricted deck

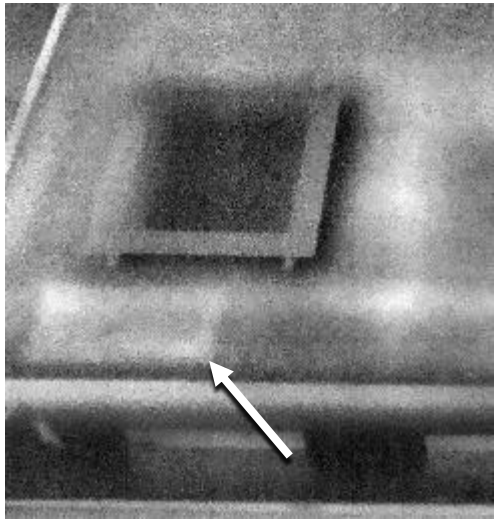


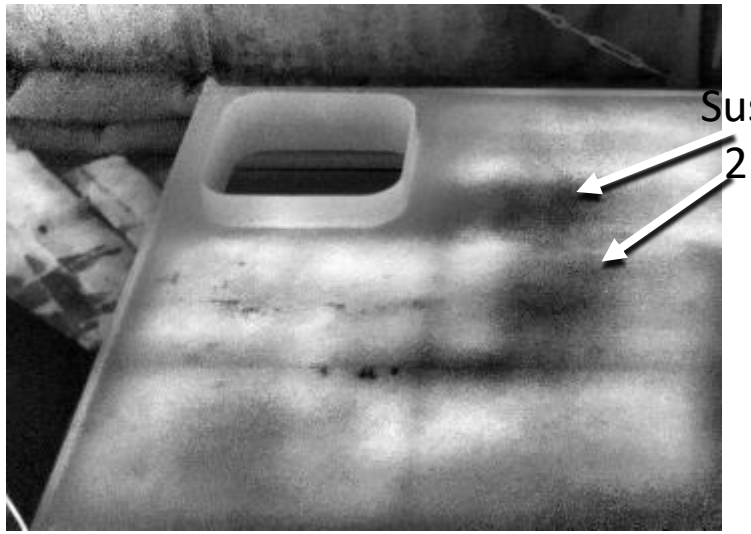
general corrosion

dim circle





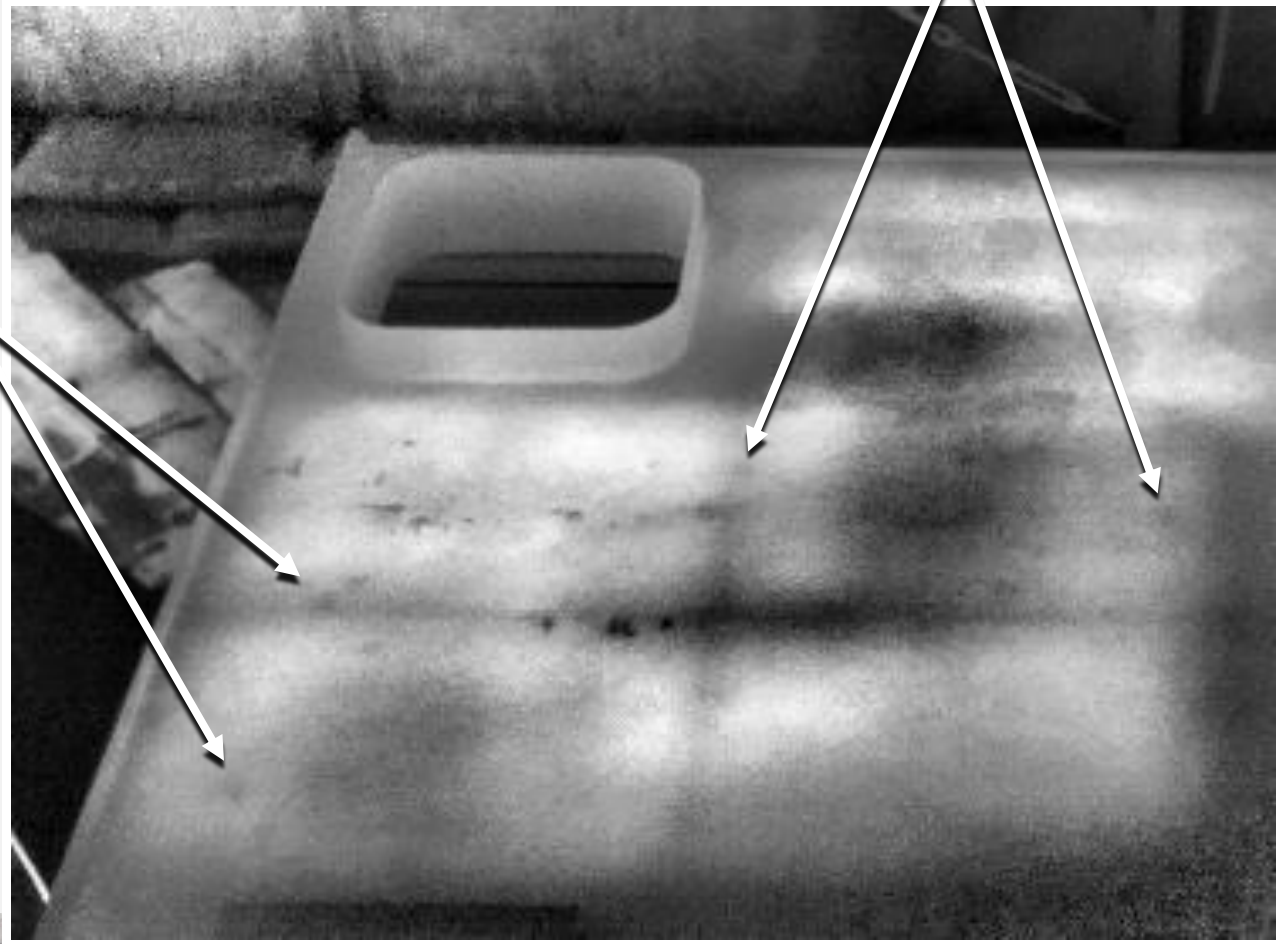




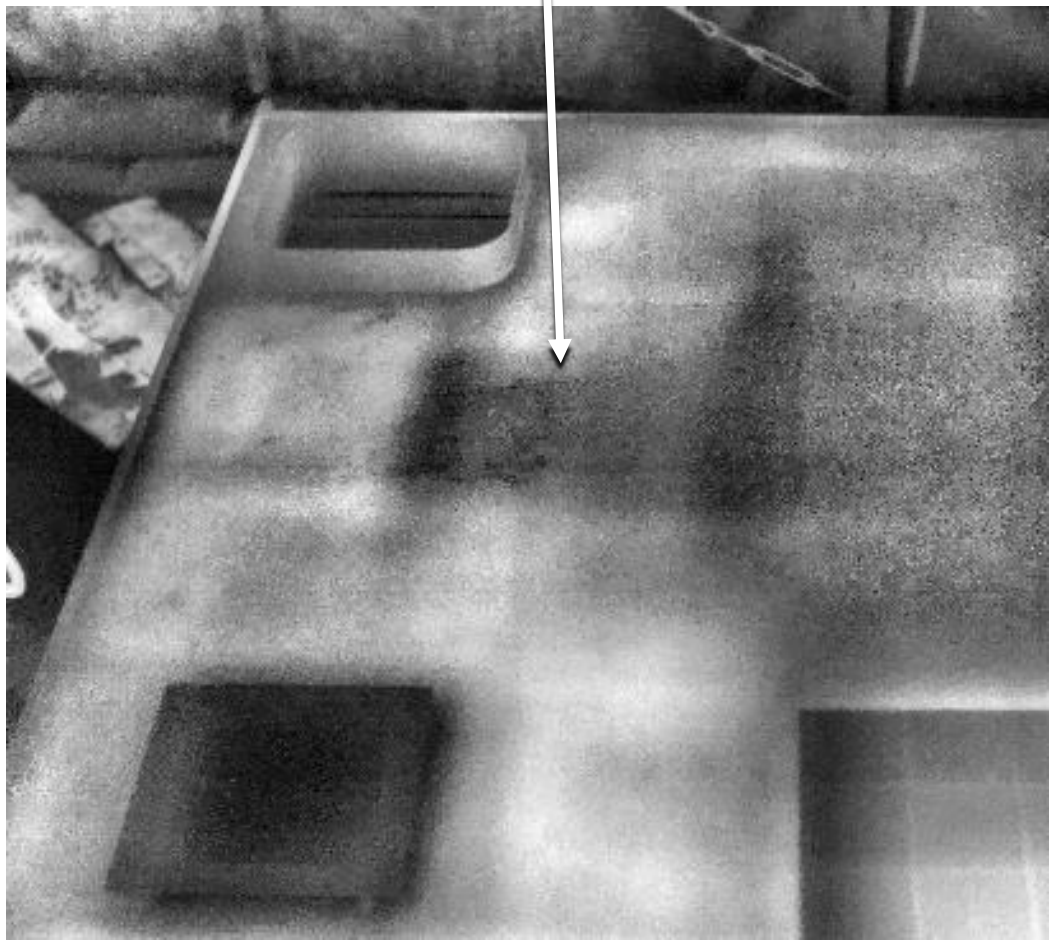
Suspicious
2 circles

Unrestricted deck

Suspicious
smaller spots

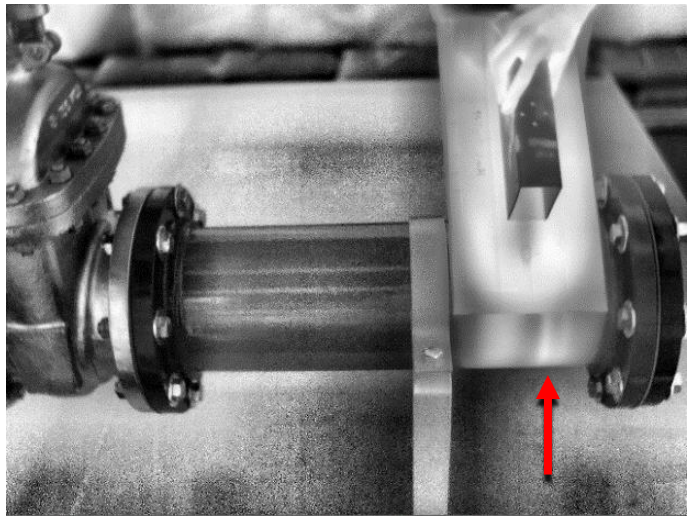


Square. Could also be a heating artifact

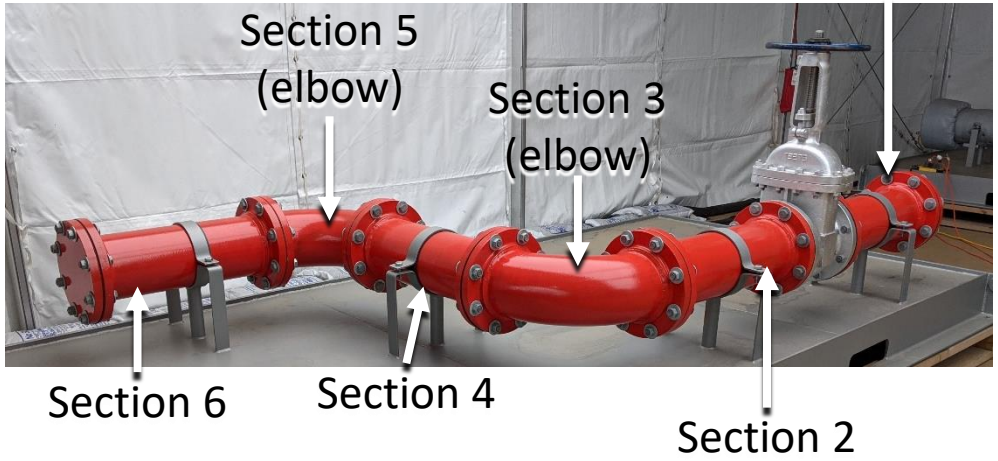


Piping (front side) (200045?)

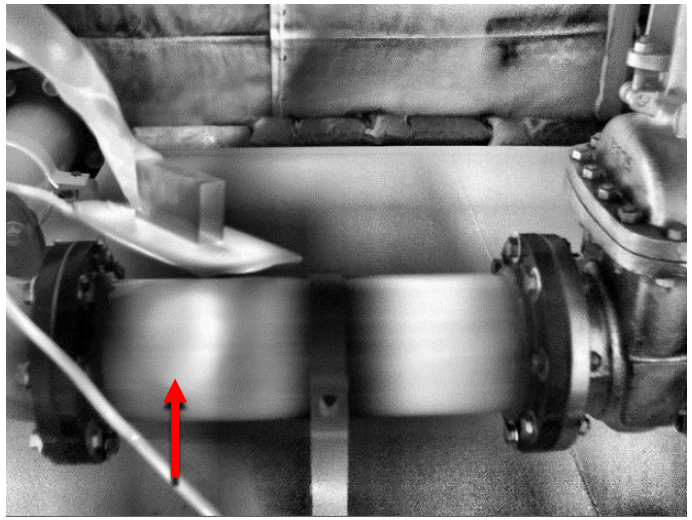
Section 1



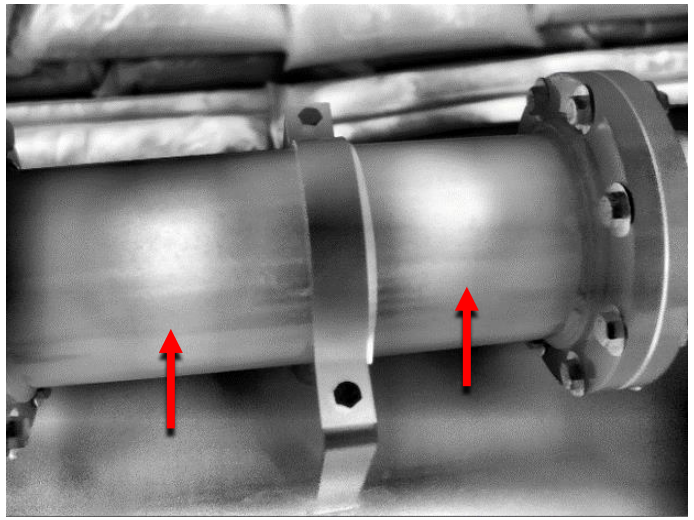
Section 1



Section 2



Section 6

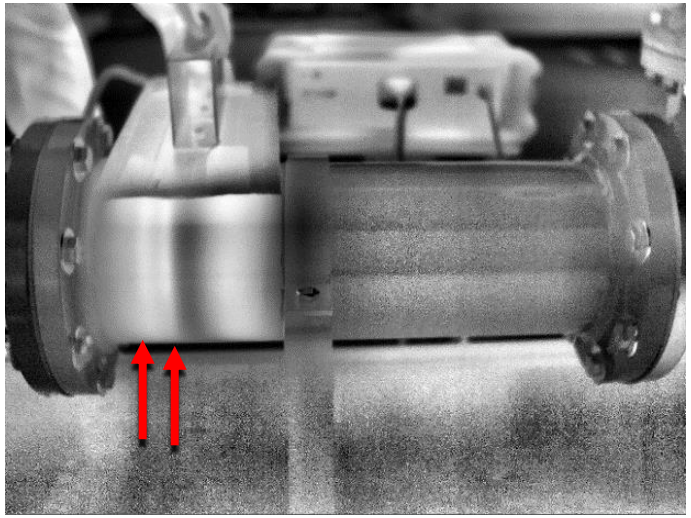


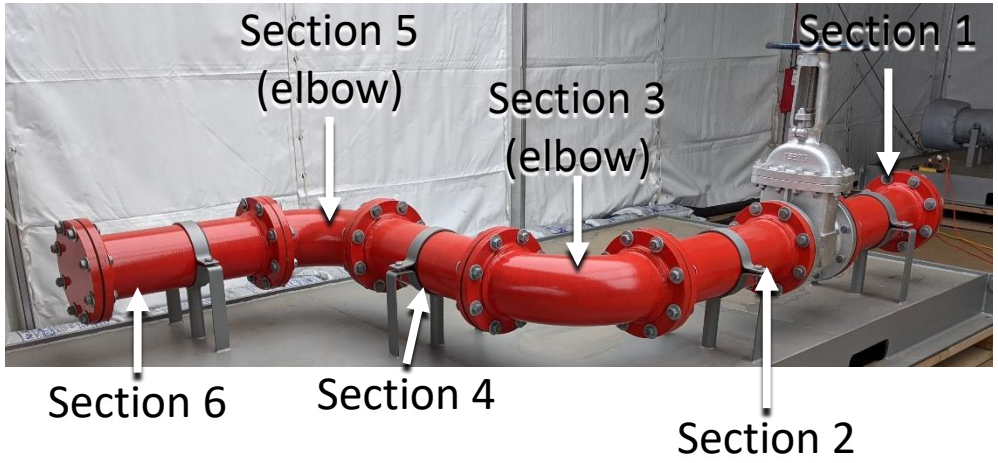
Notes:

- A rectangular flat coil is not well-suited for pipes. A smaller or curved coil may potentially yield better results.

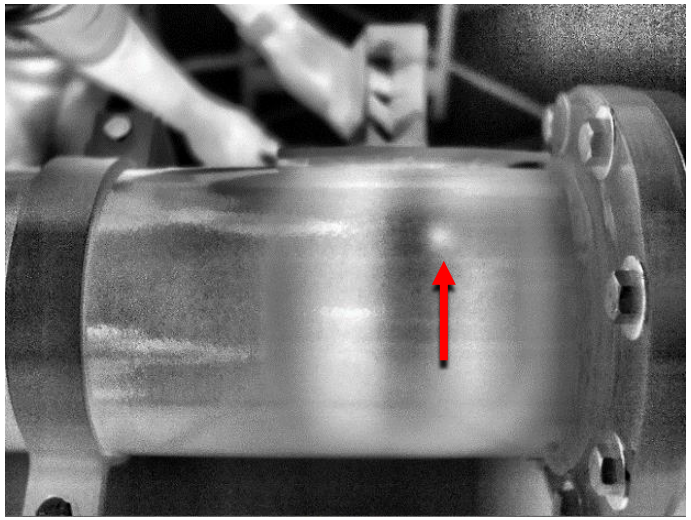
Piping (back side)

Section 2

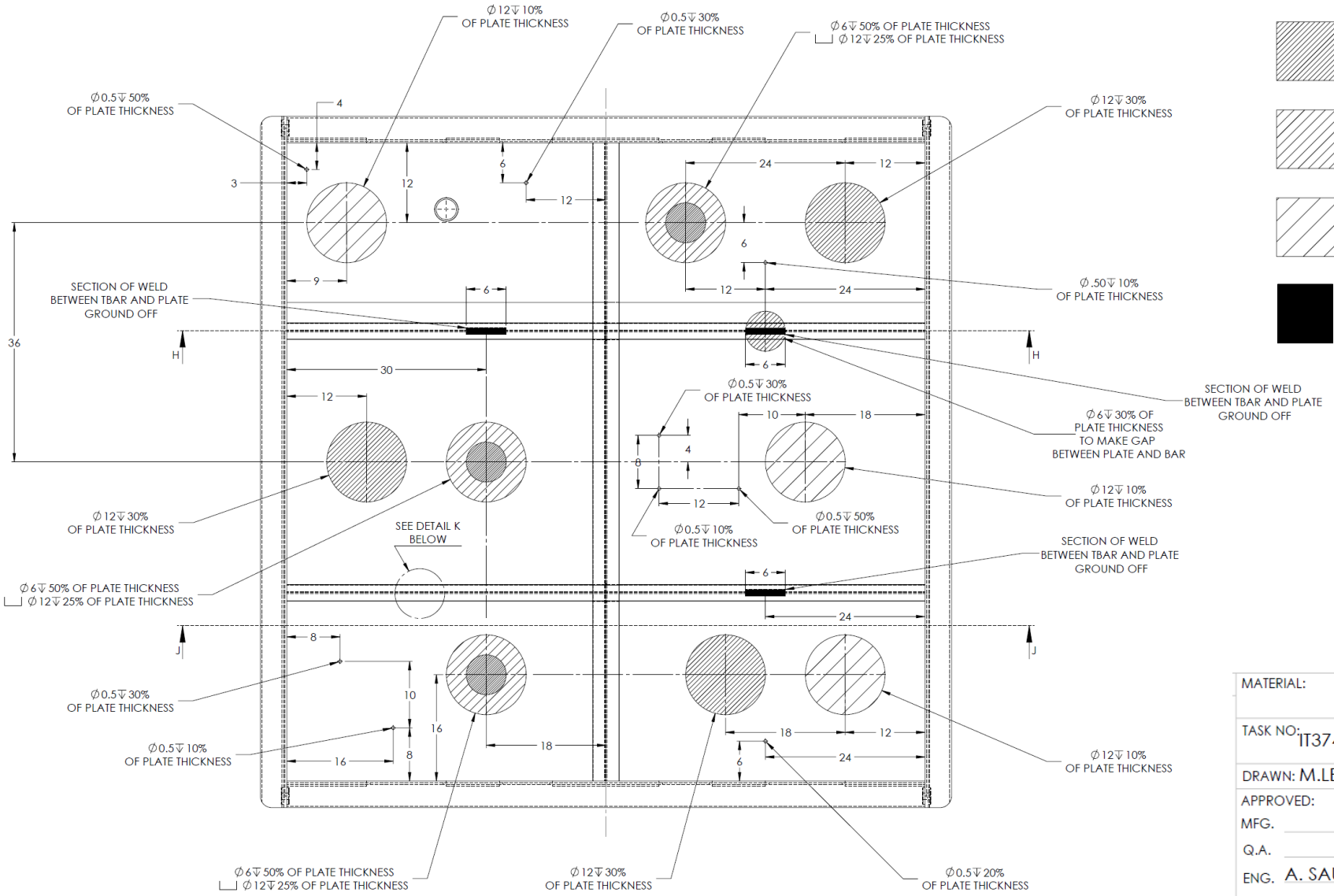




Section 1



Hull plate (100400), (back view)

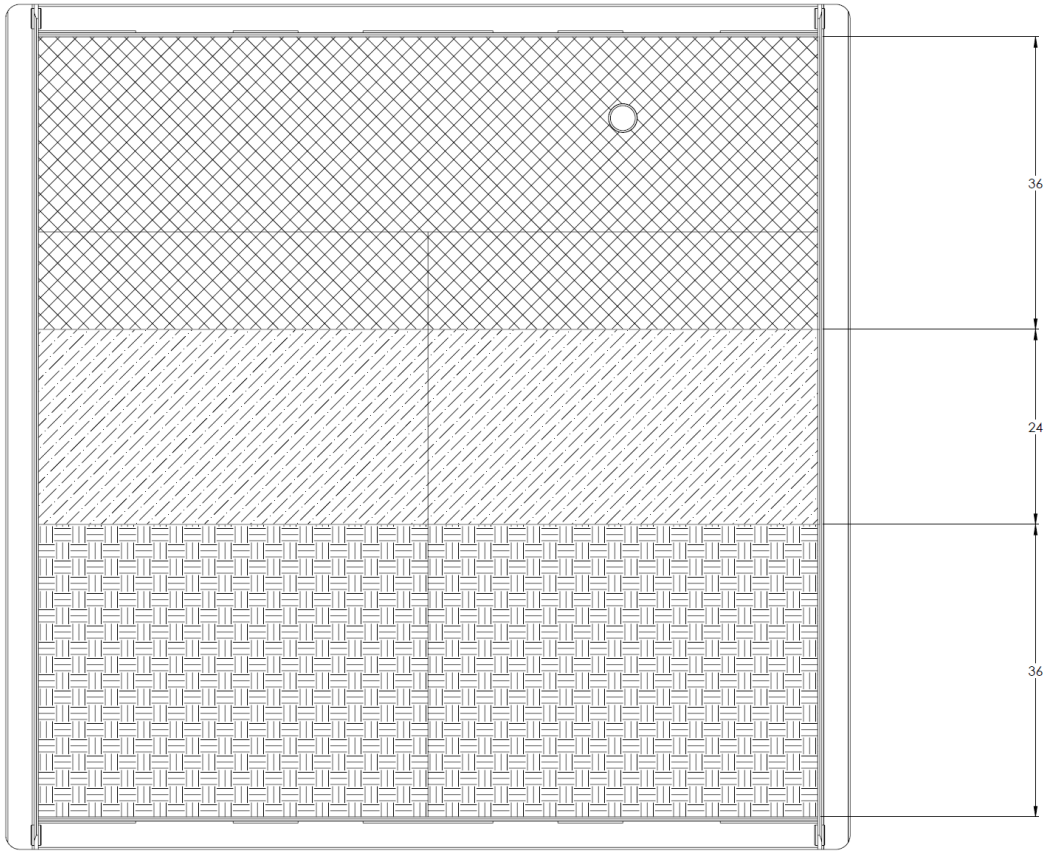


NOTE: SURFACE FEATURES TO BE GROUND INTO BOTTOM FACE AS CLOSE AS POSSIBLE TO TARGET DEPTH

- ↧ 50% OF PLATE THICKNESS (50% REMAINING)
- ↧ 30% OF PLATE THICKNESS (70% REMAINING)
- ↧ 25% OF PLATE THICKNESS (75% REMAINING)
- ↧ 10% OF PLATE THICKNESS (90% REMAINING)
- SECTION OF WELD GROUND OFF

MATERIAL:	2.0	FINISH:	3.0
TASK NO: IT3746-S	NAVAL ENGINEERING TEST ESTABLISHMENT (NETE) HALIFAX, NOVA SCOTIA, CANADA		
DRAWN: M.LEGGE	TITLE: HULL PLATING TESTBED		
APPROVED:			
MFG.			
Q.A.			
ENG. A. SAULNIER	SIZE D	DWG. NO. 100400	REV 1
	SCALE: 1:10	WEIGHT: 1612.54 LBS	SHEET 3 OF 8

Hull plate (100400)

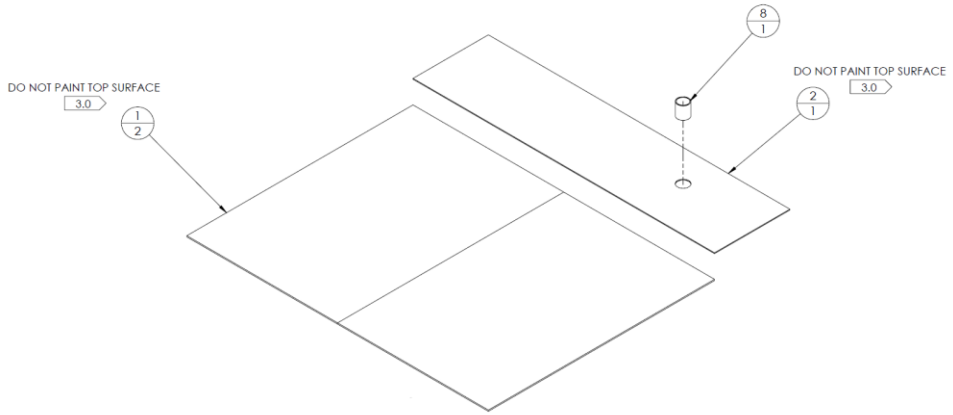


HULL PAINT (INTERLEC) - GREY

BOOT TOP (INTERSPEED) - BLACK

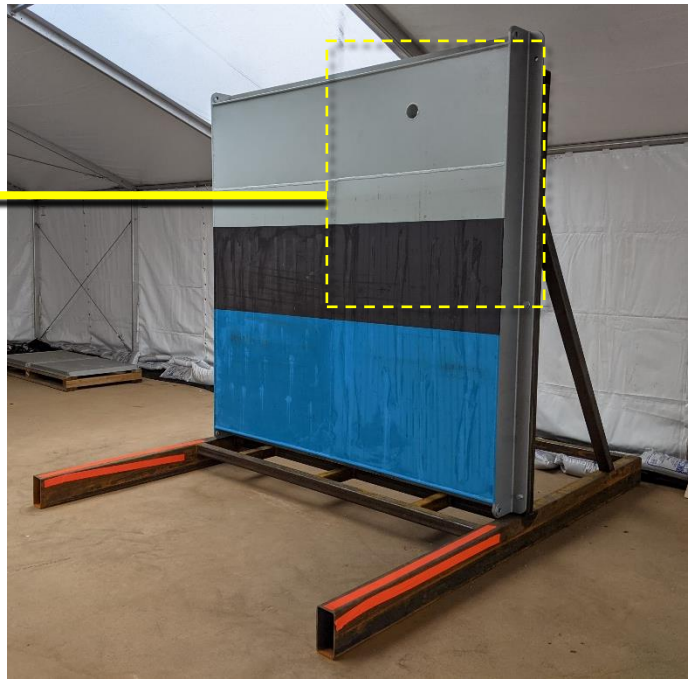
ANTIFOULING COATING (INTERSPEED) - BLUE

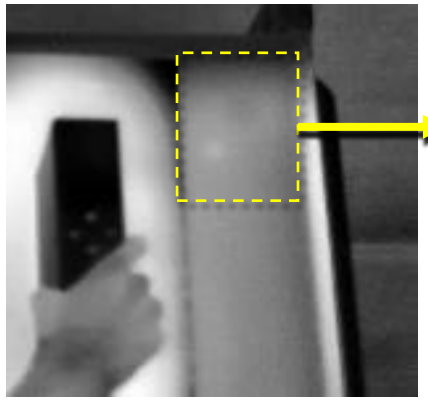
NOTE: HULL PAINT/COVERINGS TO BE INSTALLED AS PER HALIFAX CLASS FRIGATE SPECIFICATIONS

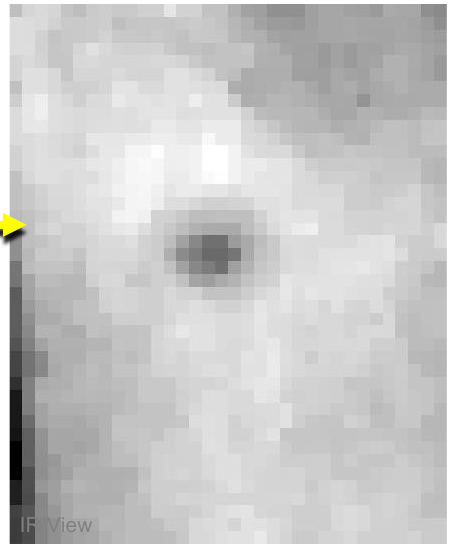


ITEM NO.	PART	DESCRIPTION	QTY.	CUT LENGTH
8	PIPE	PIPE, 3", SCH. 40	1	4"
7	EYELET REINFORCEMENT	BAR, STEEL, 2.5" DIA, 0.375" THK	8	N/A
6	FRAME	T BAR, STEEL, 6" x 4" x 0.25"	1	96"
5	LONGINTUDINAL	T BAR, STEEL, 4.5" x 2.5" x 0.1875"	2	96"
4	FRAME EDGE - SHORT	ANGLE BAR, STEEL, 8" x 4" x 0.5"	2	96"
3	FRAME EDGE - LONG	ANGLE BAR, STEEL, 8" x 4" x 0.5"	2	104"
2	HULL PLATE	PLATE, STEEL, 7mm THK	1	95" X 24"
1	HULL PLATE	PLATE, STEEL, 9mm THK	2	72" X 48"

Hull plate (100400)



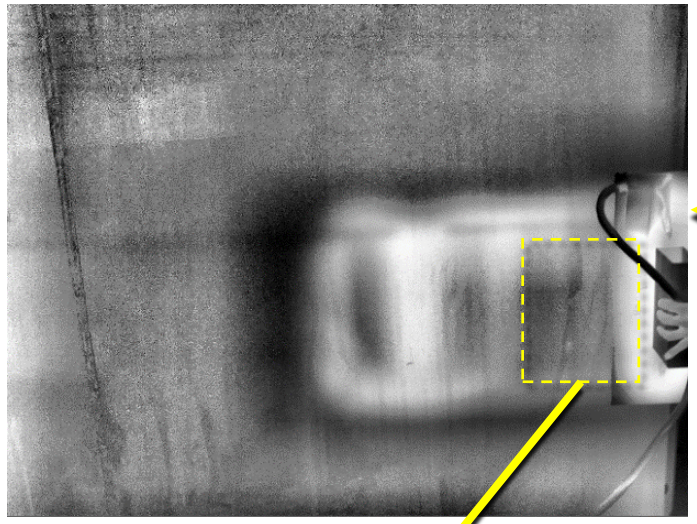


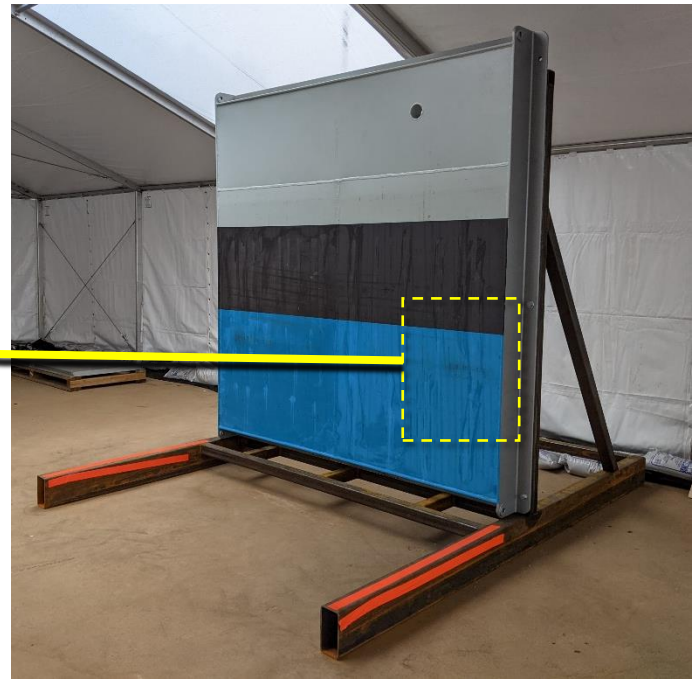


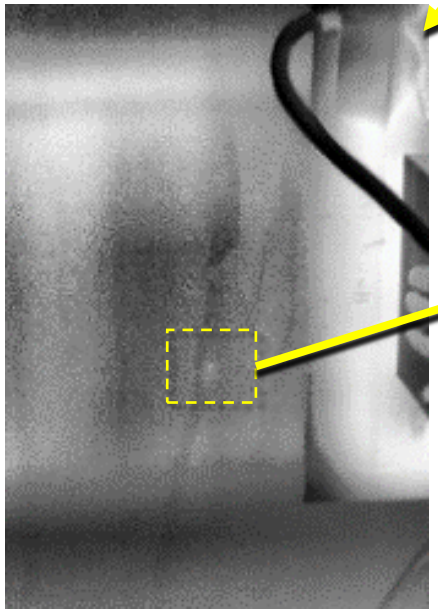
Visible pitting in raw.

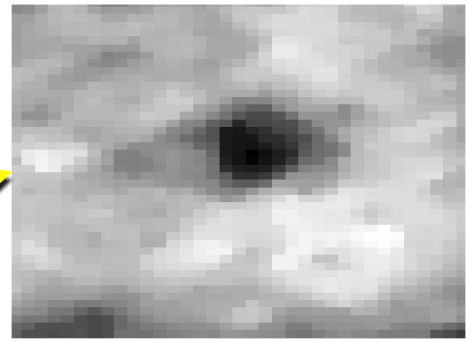
Advanced processing with PCT EOF5 using 91 frames can clearly reveal the pitting corrosion.

Hull plate





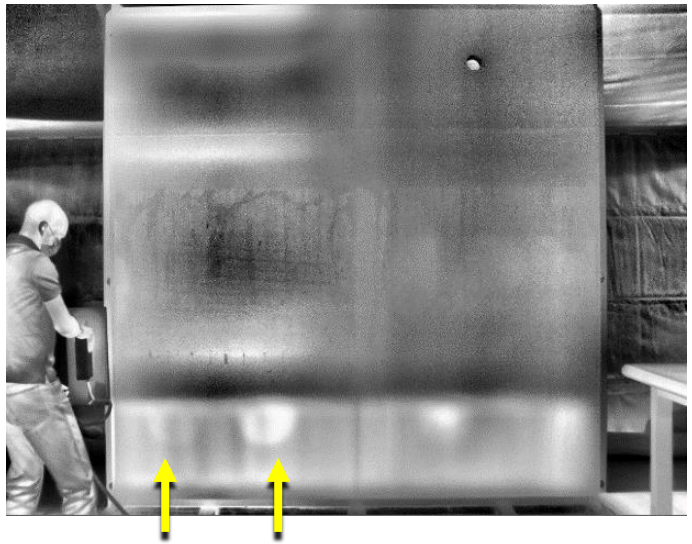


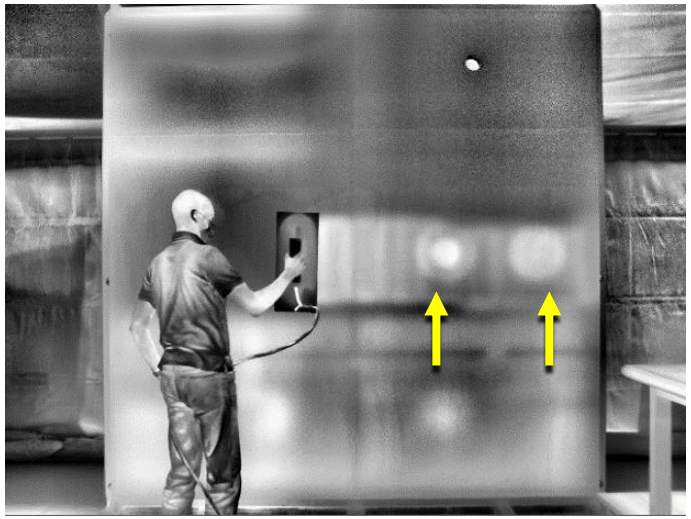


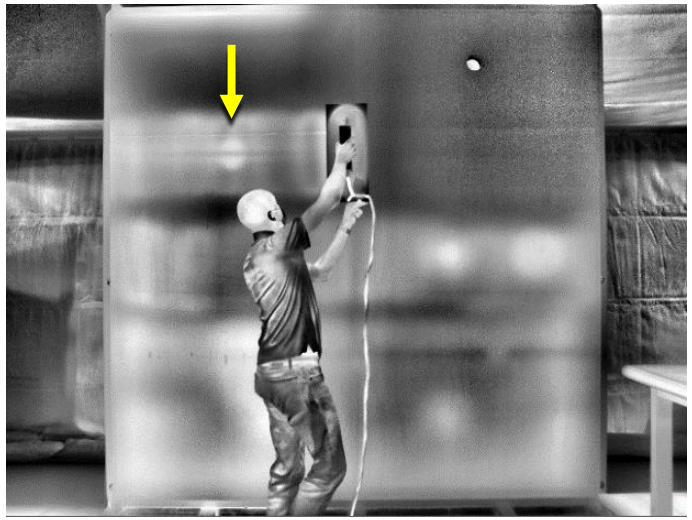
Advanced processing with PCT EOF3 using 69 frames can clearly reveal the pitting corrosion.

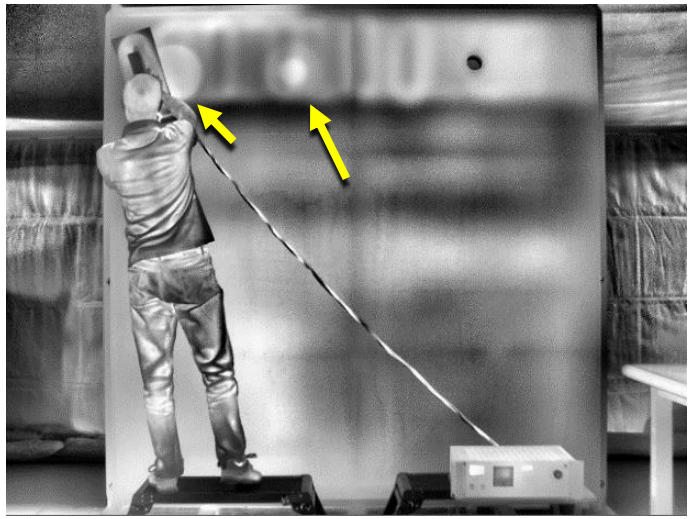
Pitting visible in RAW.

Hull plate

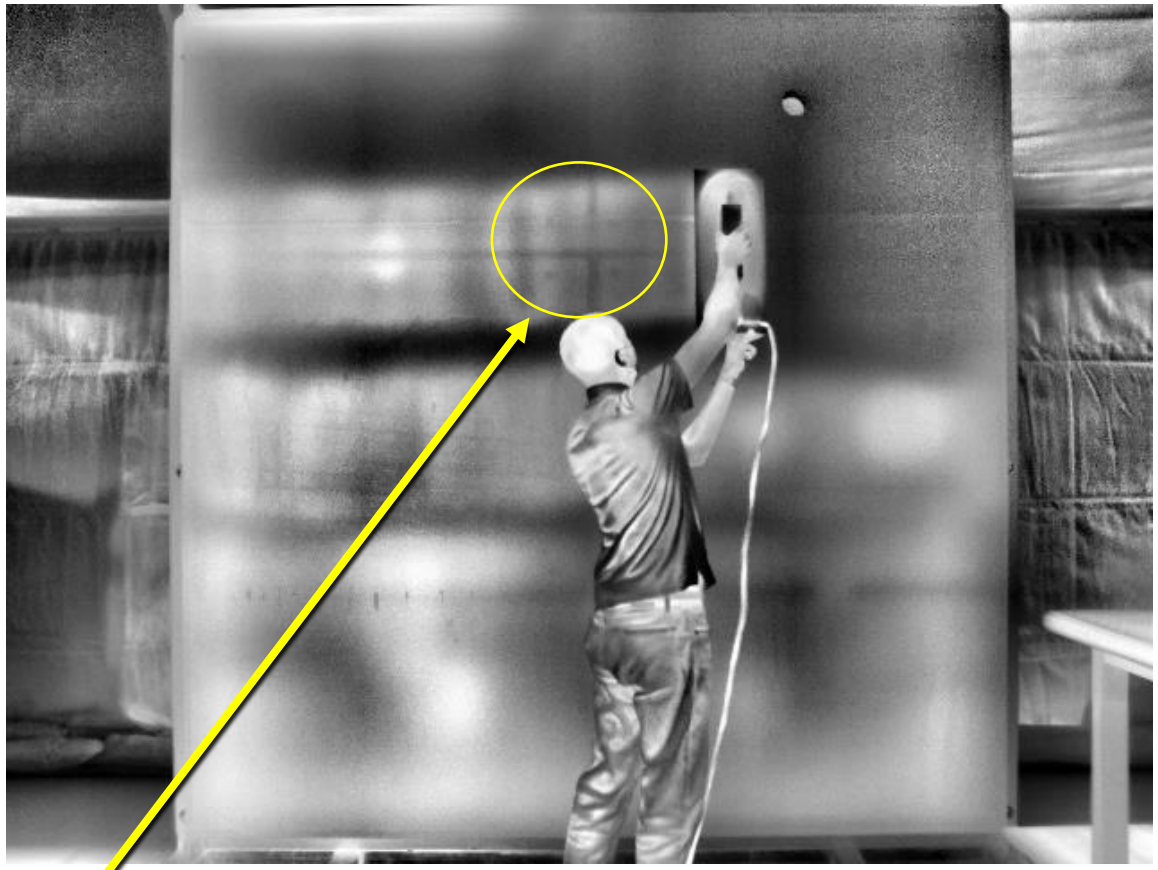






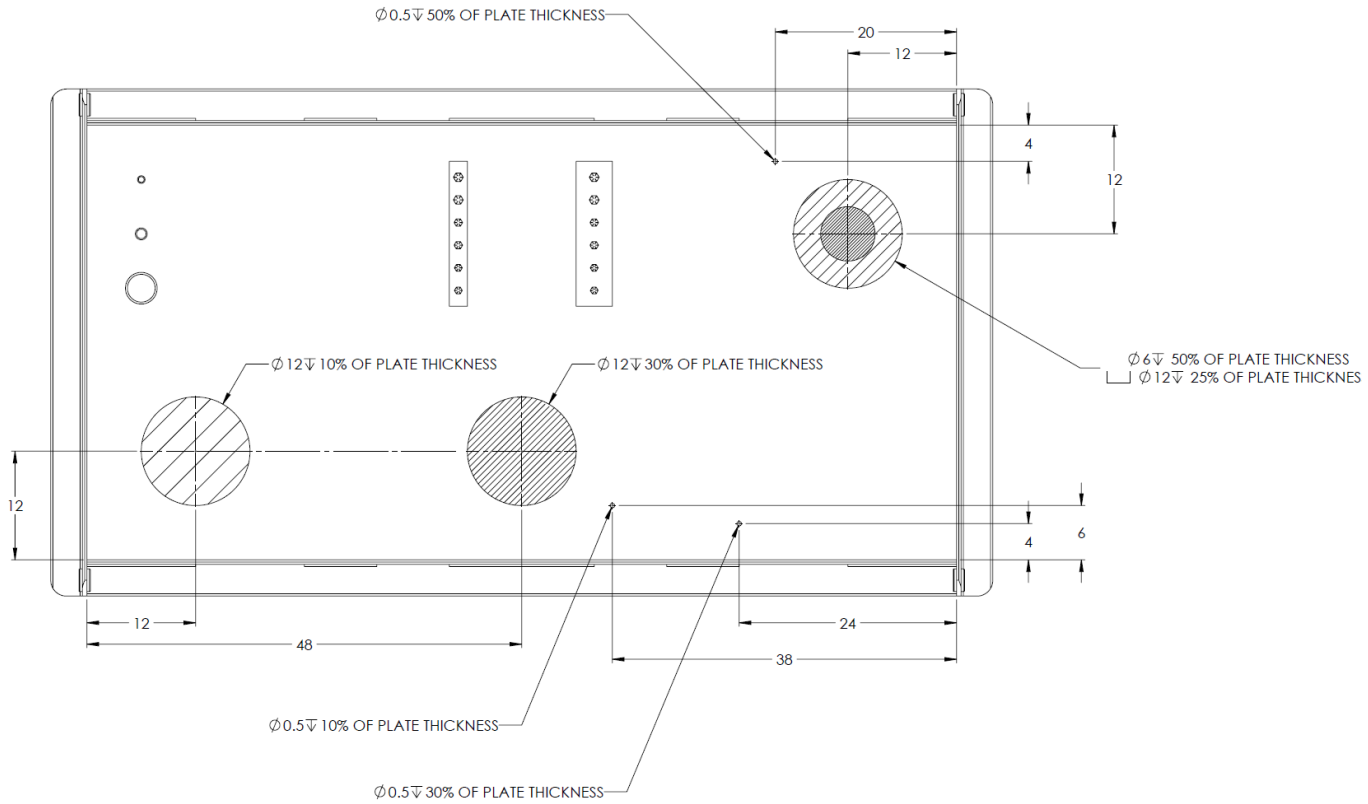


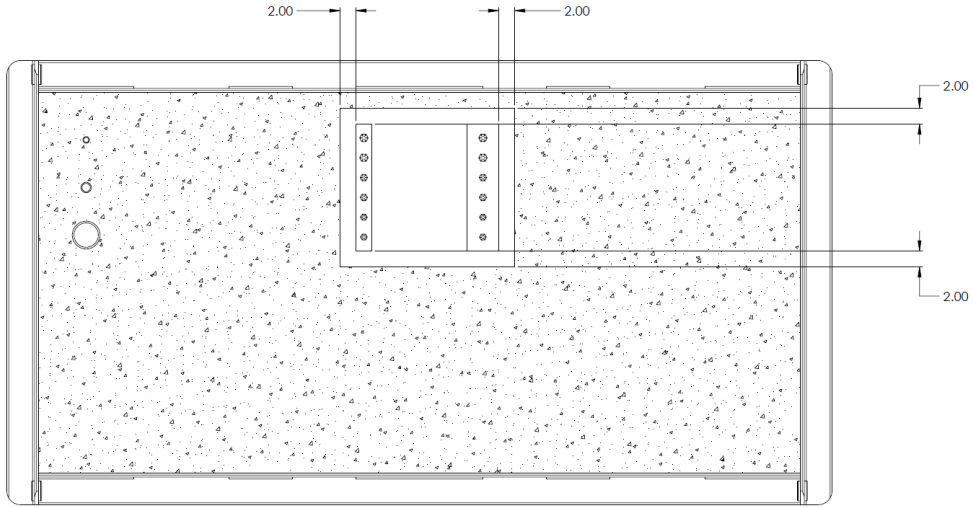
Hull plate



There are two groups of four darker spots, possibly indicating the presence of fasteners.

Restricted deck (100396)





DECK COVERING DETAIL

NOTE: SURFACE FEATURES TO BE GROUND INTO TOP FACE AS CLOSE AS POSSIBLE TO TARGET DEPTH

↧ 50% OF PLATE THICKNESS (50% REMAINING)

↧ 30% OF PLATE THICKNESS (70% REMAINING)

↧ 25% OF PLATE THICKNESS (75% REMAINING)

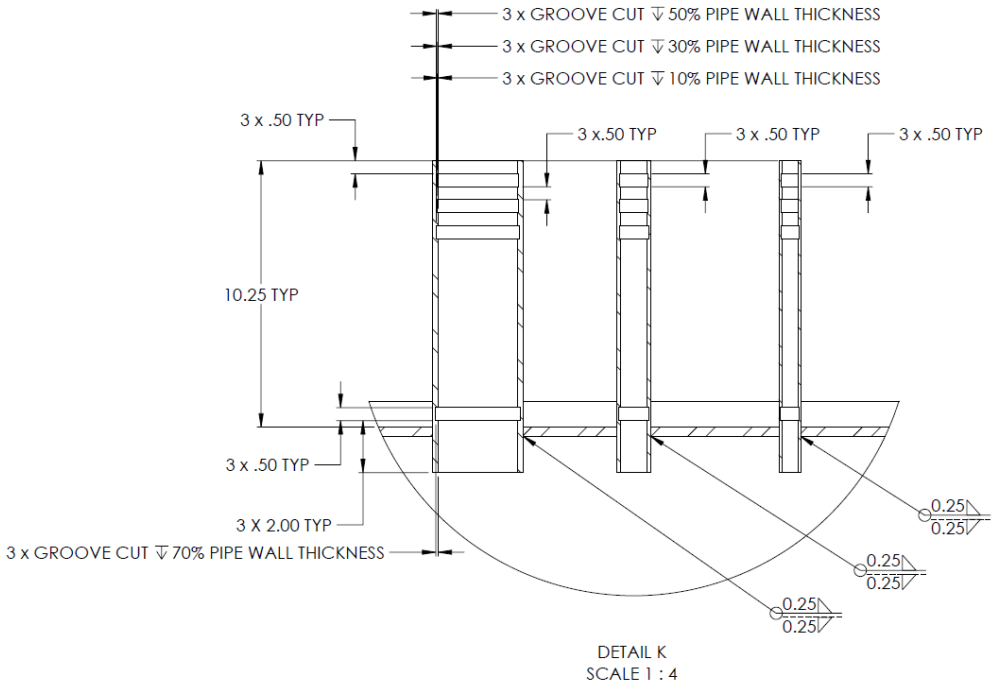
↧ 10% OF PLATE THICKNESS (90% REMAINING)

NONSKID DECKING

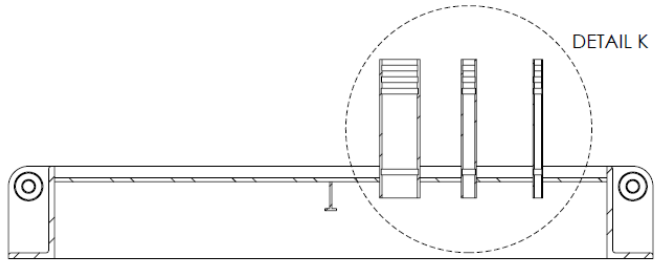
NO COVERING - PRIMED STEEL

NOTE: DECK COVERINGS TO BE INSTALLED AS PER HALIFAX CLASS FRIGATE SPECIFICATIONS

Restricted deck (100396)

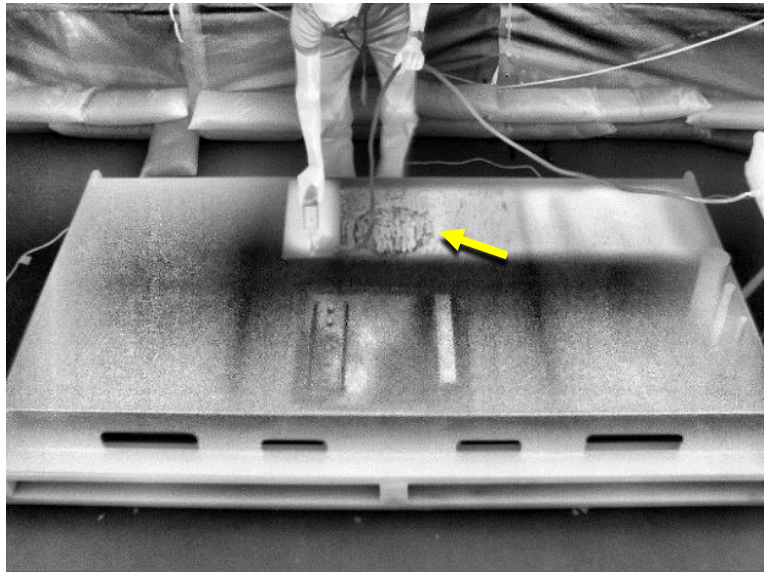


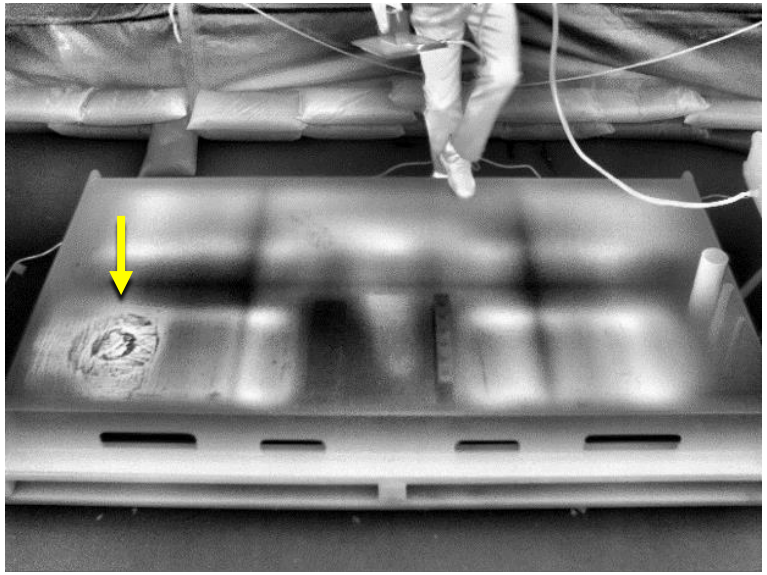
DETAIL K
SCALE 1 : 4



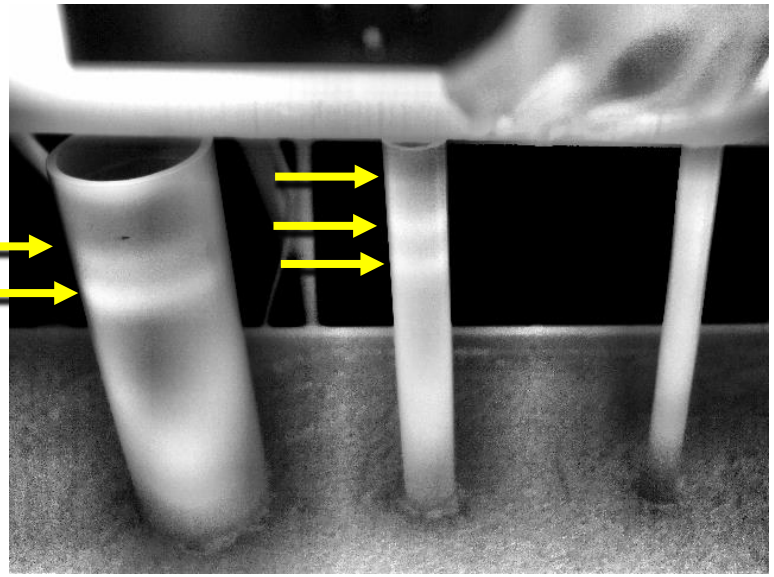
MATERIAL: 2.0		FINISH: 3.0	
TASK NO: IT3746-S	NAVAL ENGINEERING TEST ESTABLISHMENT (NETE) HALIFAX, NOVA SCOTIA, CANADA		
DRAWN: M.LEGGE	TITLE: CREVICE CORROSION TESTBED		
APPROVED:			
MFG.	SIZE D	DWG. NO. 100396	REV 1
Q.A.			
ENG. A. SAULNIER	SCALE: 1:10	WEIGHT: 1013.77 LBS	SHEET 5 OF 5

Restricted deck (100396)

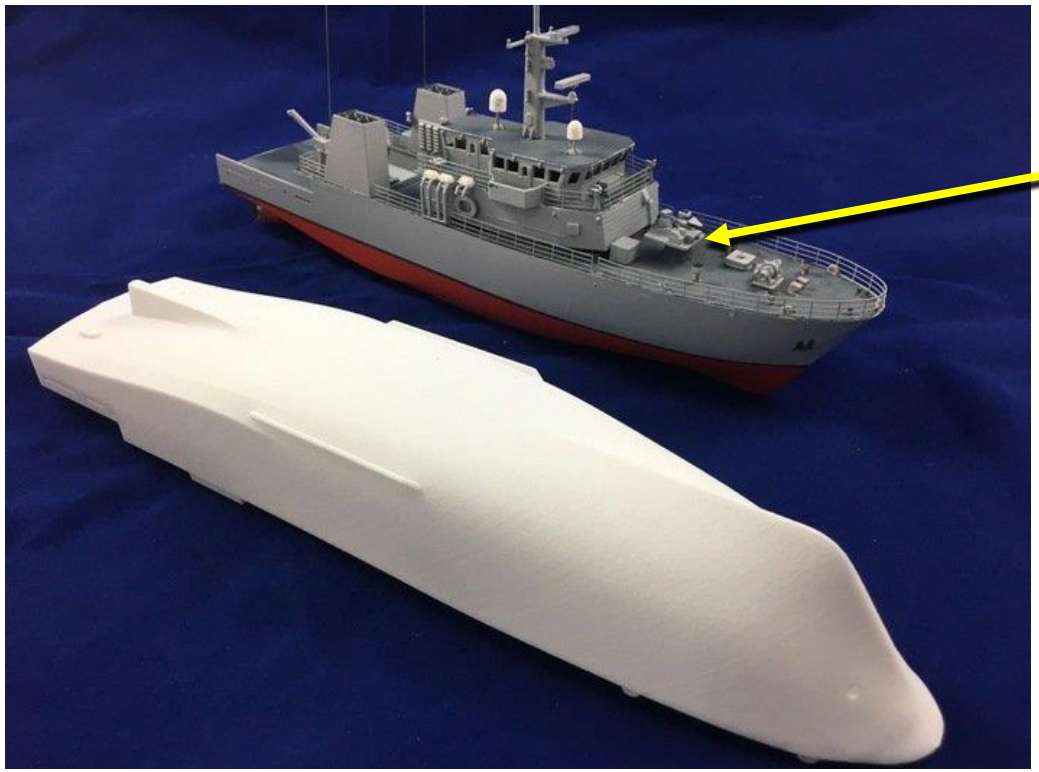


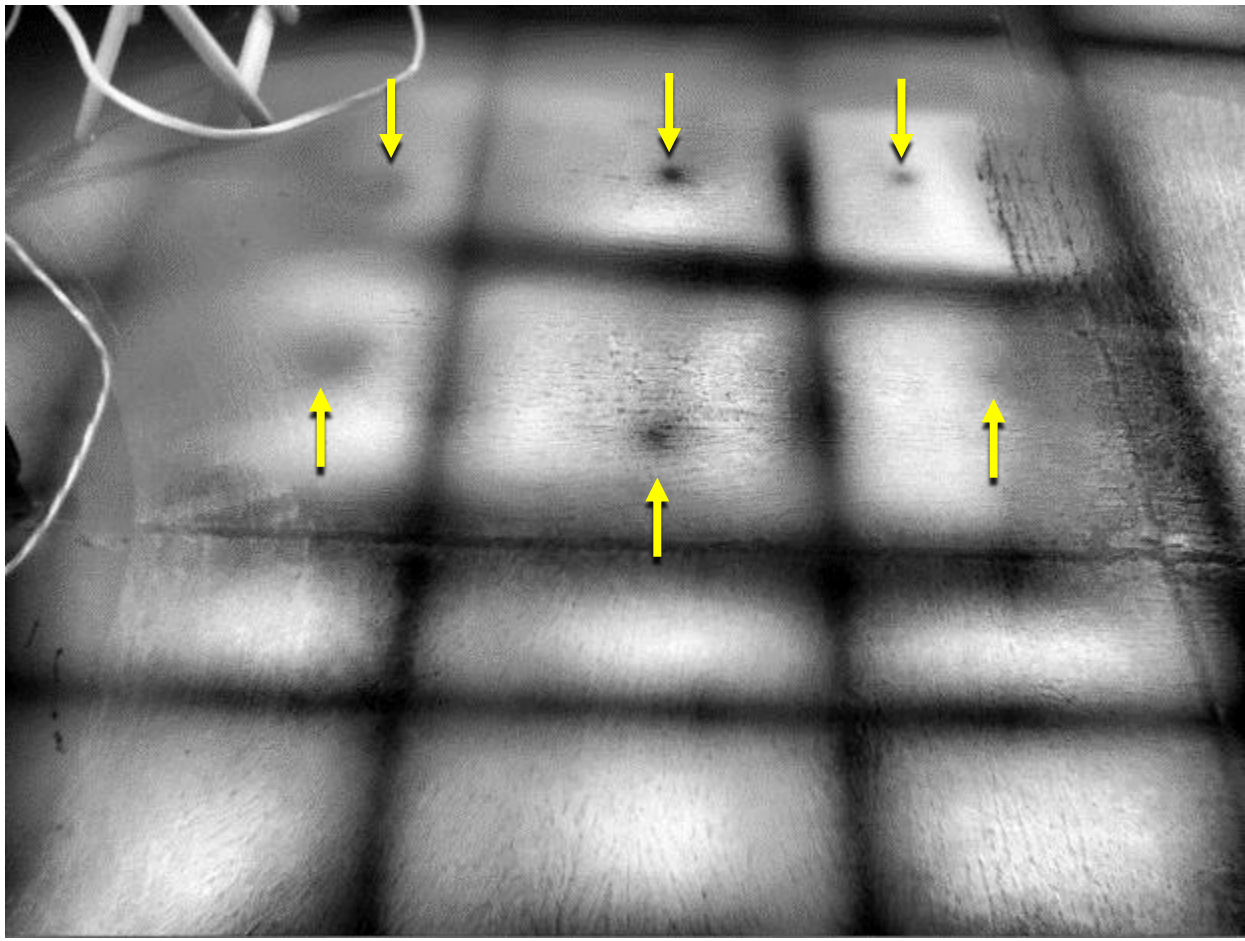


Note: The two FBH circles were visible to the naked eye. The embossing may have assisted or contributed to the infrared view.



Goose Bay #707, Kingston coastal defence vessel

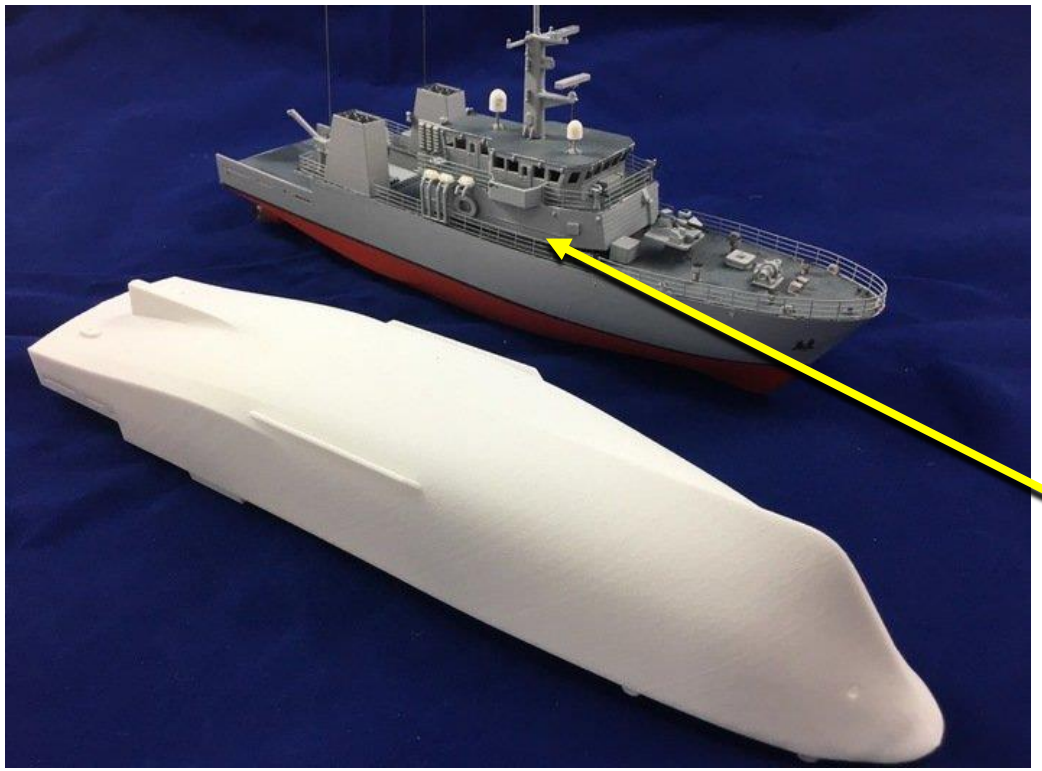


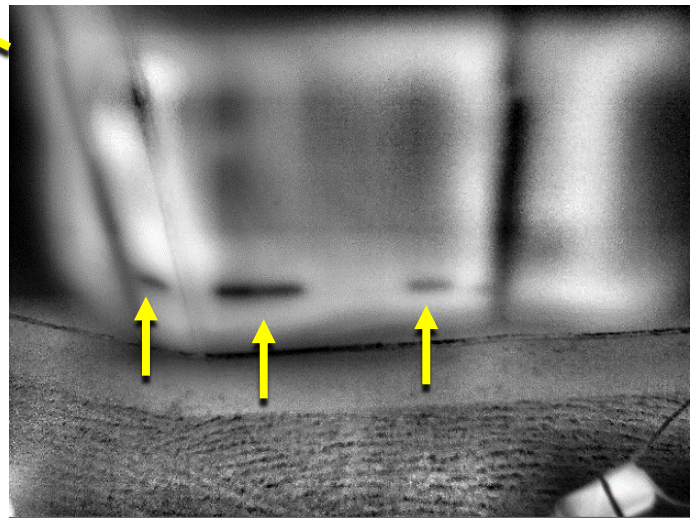


Above the refrigerating room: There are likely some fasteners or structural elements underneath the deck.

HMCS Kingston,
Credit for 3D Model: 'Micro_Boat_Hobby'
https://www.shapeways.com/product/Y59999YSY/hmcs-kingston-hull-1-200-rc?li=shareProduct

Goose Bay #707, Kingston coastal defence vessel





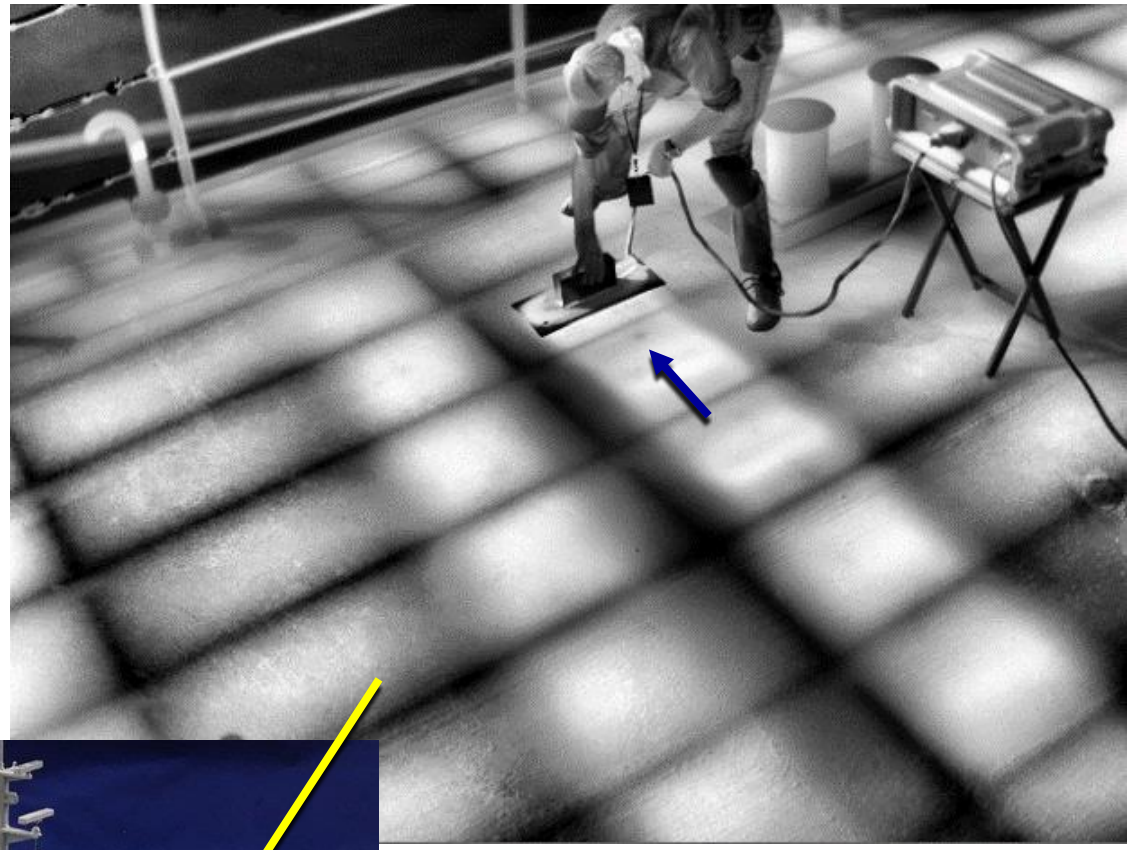
Side of the cabin, close to the ground/deck surface.

Goose Bay #707, Kingston coastal defence vessel

Before heating:

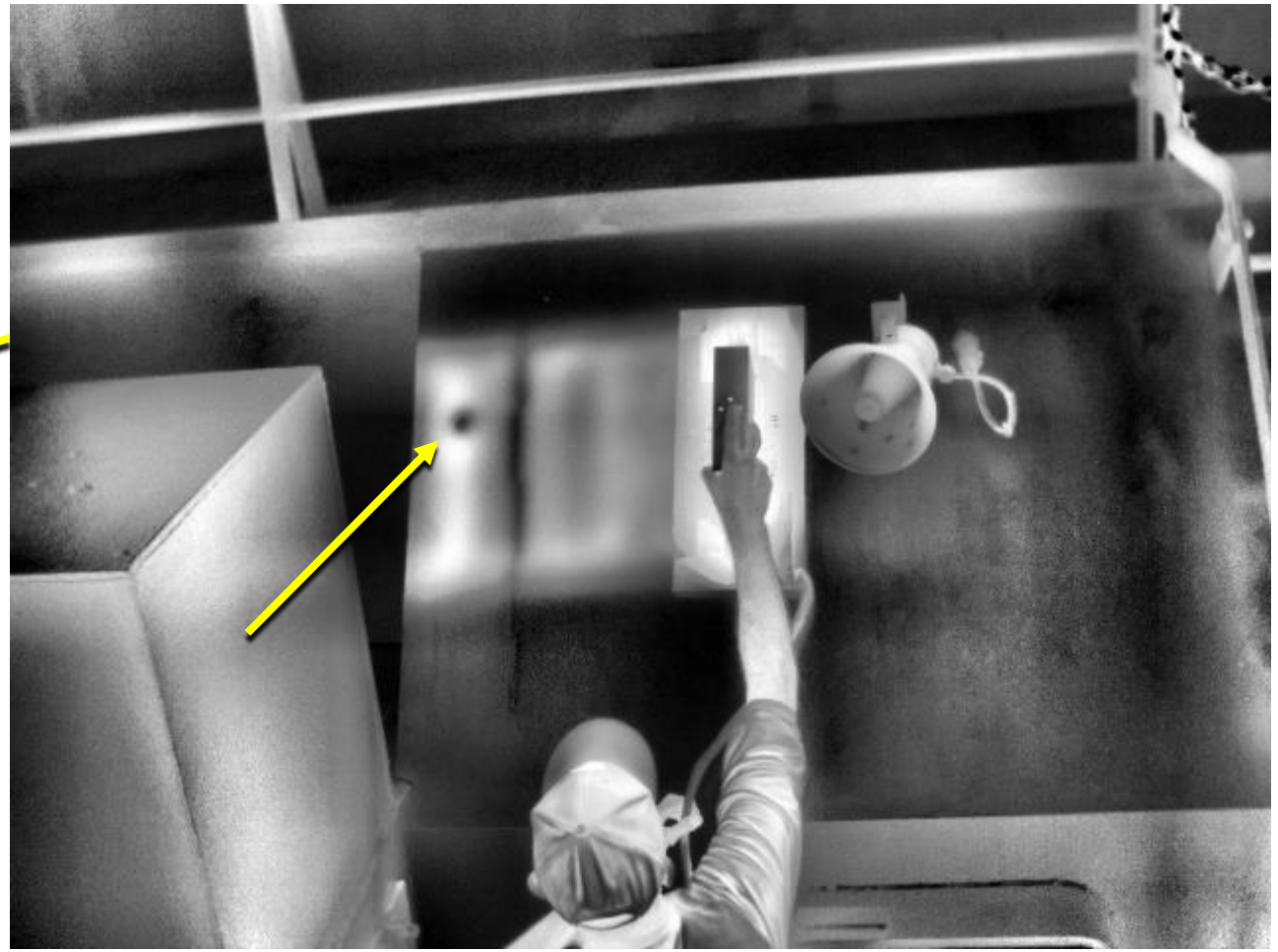
After heating, sub-paint surface corrosion, bubbles, and pitting (visible with the naked eyes) appear as black spots:

Goose Bay #707, Kingston coastal defence vessel



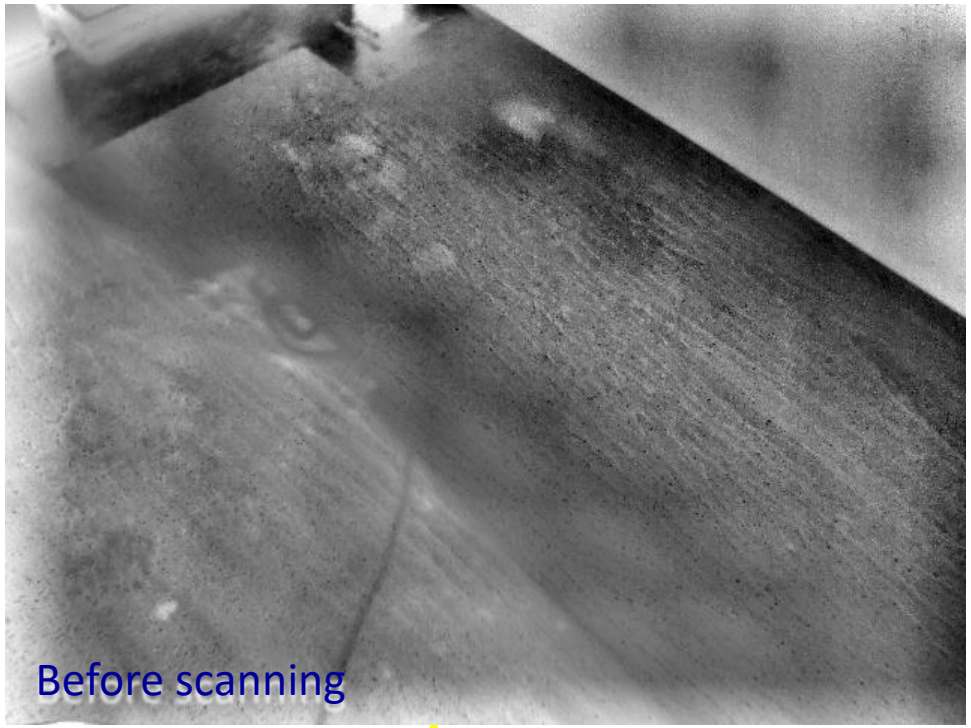
The spot on the right image was confirmed by a previous company. Some additional similar spots could be found on the left, likely fasteners.

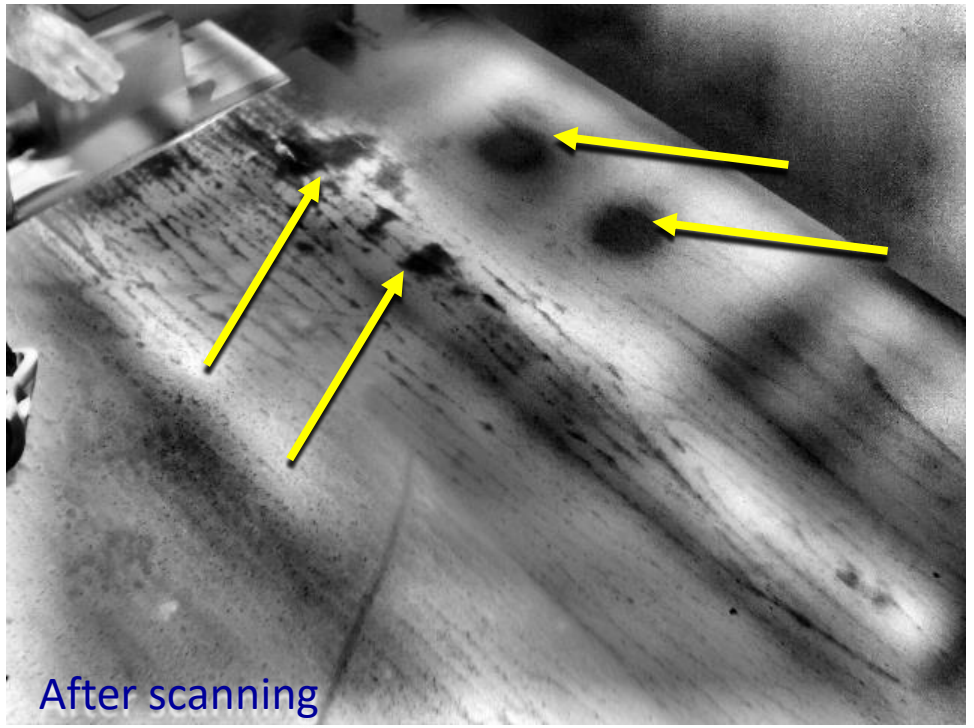
Goose Bay #707, Kingston coastal defence vessel



General corrosion spot hidden under the paint, with a visible cavity or lack of material that can be observed with the naked eye.

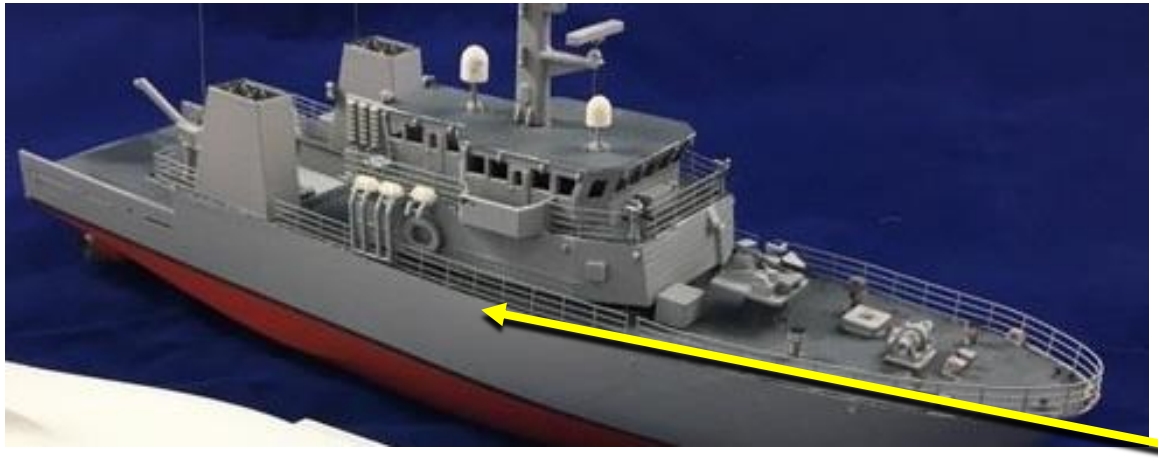
Goose Bay #707, Kingston coastal defence vessel





General corrosion spots are concealed under the paint, appearing as two circles, possibly indicating a structure underneath the upper deck.

Goose Bay #707, Kingston coastal defence vessel



Upper hull accessible from the deck. Sound structure.

Conclusions

Based on the results obtained from the inspection of various scenarios in this Sandbox, aimed at detecting and assessing corrosion behind surface coatings using Visiooimage's system:

- Eddy current thermography (ECT) has demonstrated its potential for corrosion detection in ships.
- ECT can be utilized as a standalone non-destructive testing (NDT) technique to detect general corrosion as low as 10% and pitted corrosion as low as 30% even without additional processing. With the application of additional processing techniques, it becomes possible to detect smaller corrosion instances.
- For cases of general corrosion (under 10%) and pitted corrosion (under 30%), ECT can serve as a rapid scanning NDT method to identify suspected corroded areas. It can be combined with other NDT techniques for confirmation and quantification of the damage.
- Advanced signal processing techniques can aid in defect characterization, such as determining the depth and size of corroded areas.
- Weather conditions play a role in defect detectability, particularly direct solar exposure and wet surfaces should be avoided during inspections.
- Further development and optimization of coils could enhance operation and improve corrosion detectability. Customized coil sizes for specific applications, such as scanning floors around pipes or hulls from the deck, could be beneficial.
- Additional improvements are needed to facilitate scanning, such as lift-adjustable wheels, cardan-based shaft handles for the coil (similar to a vacuum brush handle) for convenience, and longer cables
- Integration of a high-definition IR camera on a helmet with a wearable display through glasses would enable a single operator to handle scanning, data viewing, archiving, and reporting tasks. Proper integration of existing wearable displays is necessary for practical implementation.