•ADVANCES IN NDT INSPECTION OF CJP WELDS

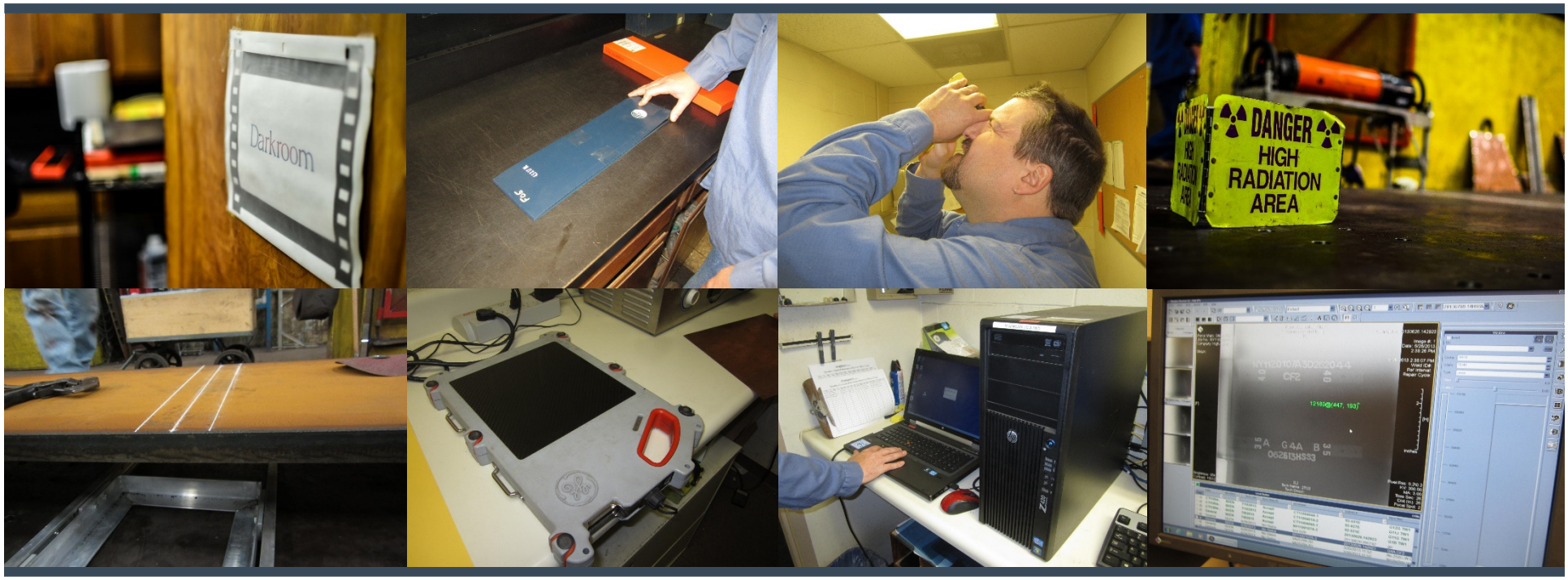
BILL VIA (VDOT) & BOB STACHEL (HRV, INC)

Agenda

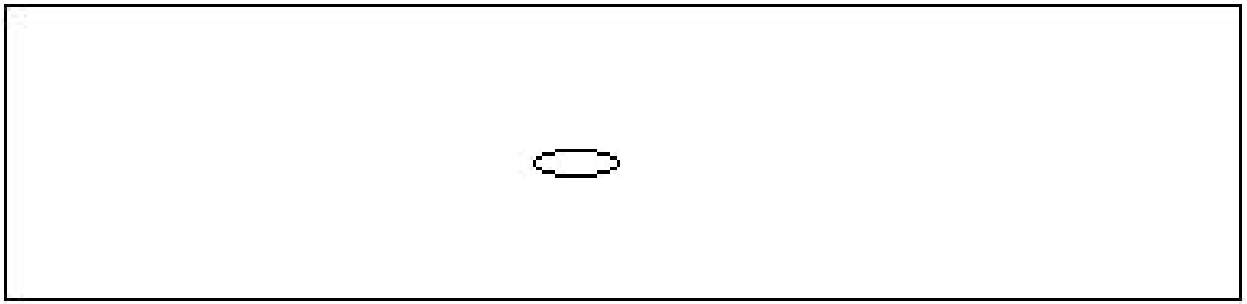
- Introduction
- Advances in Radiography
- Research Efforts – Phased Array Inspection
- Recent Phased Array Equipment & Technology
- Conclusions
- Audience Input & Questions

- Advances in Radiography

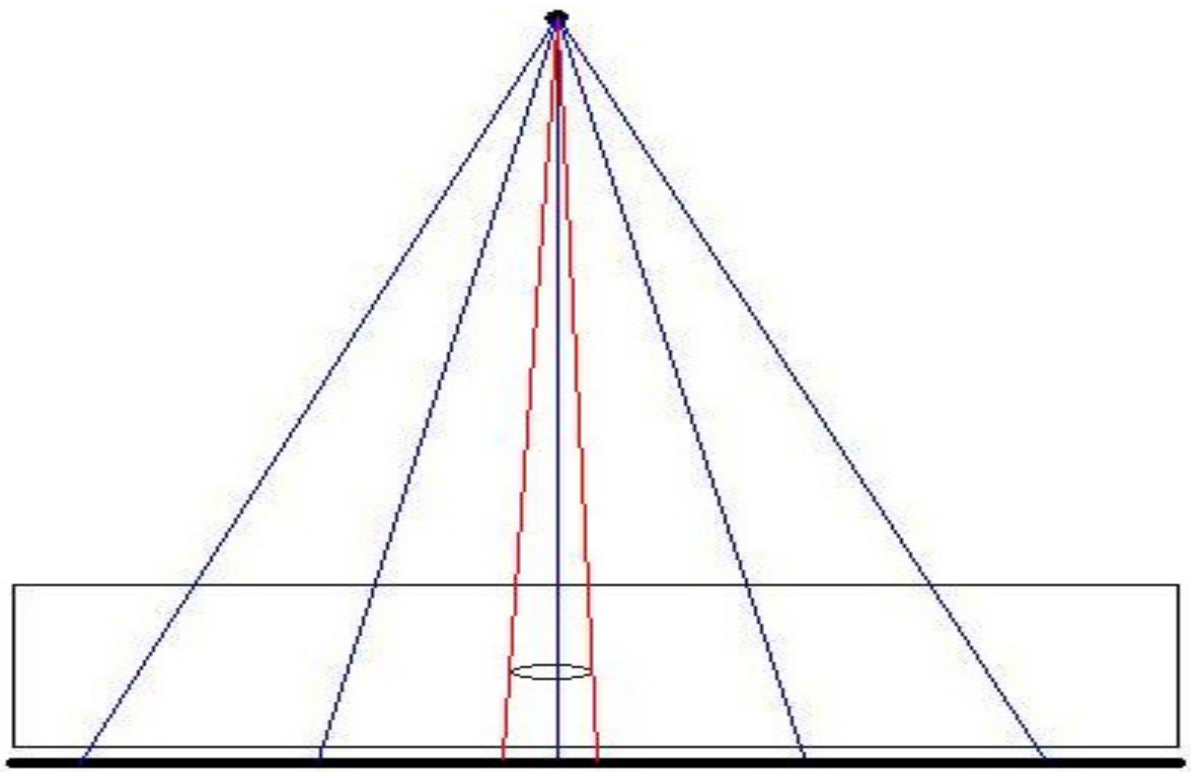
QAW Delaware – RT Presentation



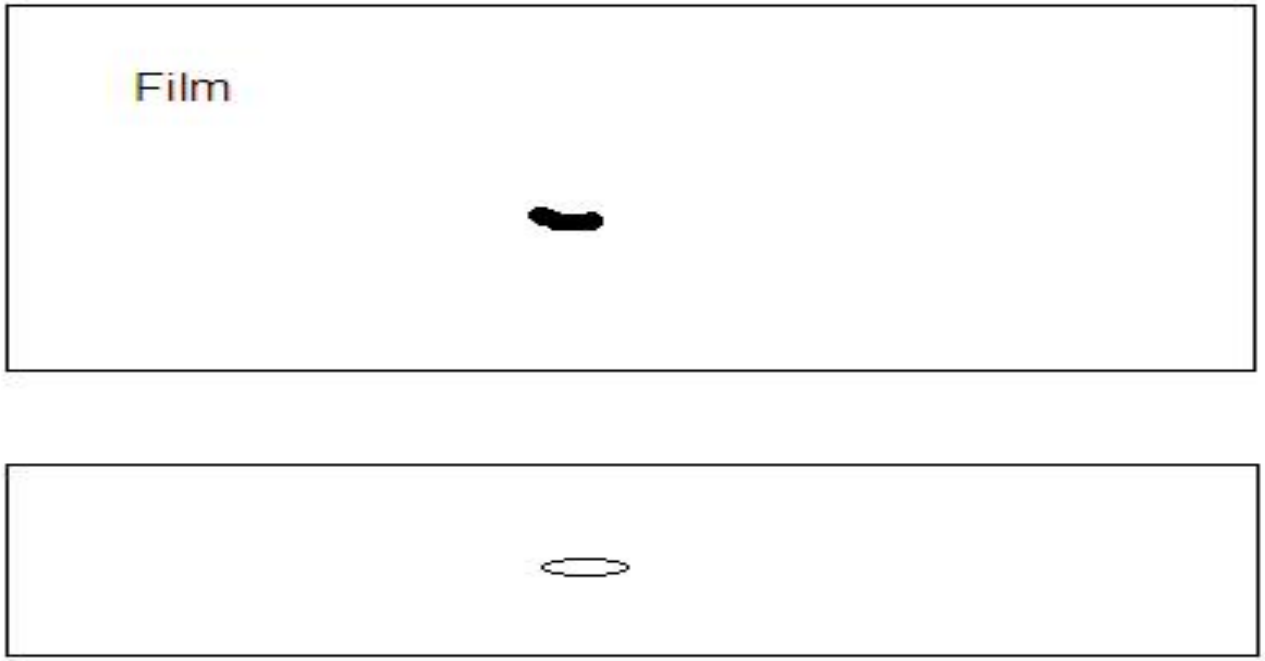
Radiographic Testing Basic Concepts



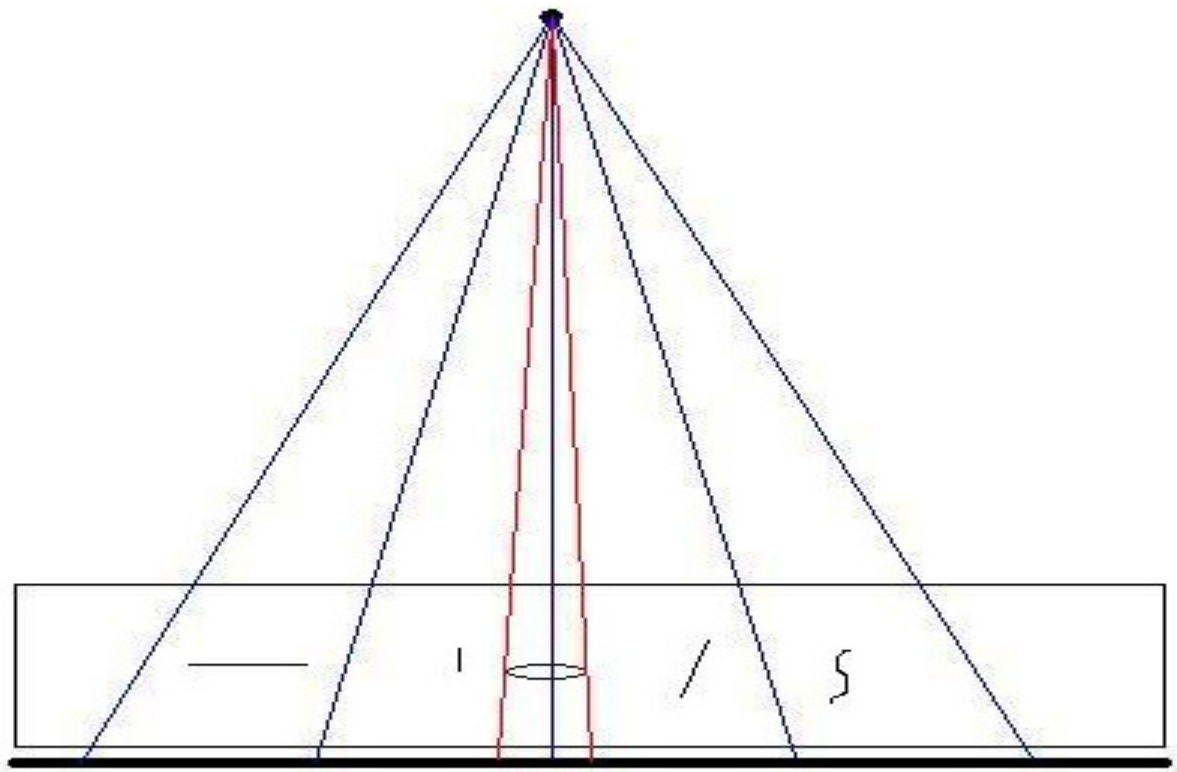
Radiographic Testing Basic Concepts



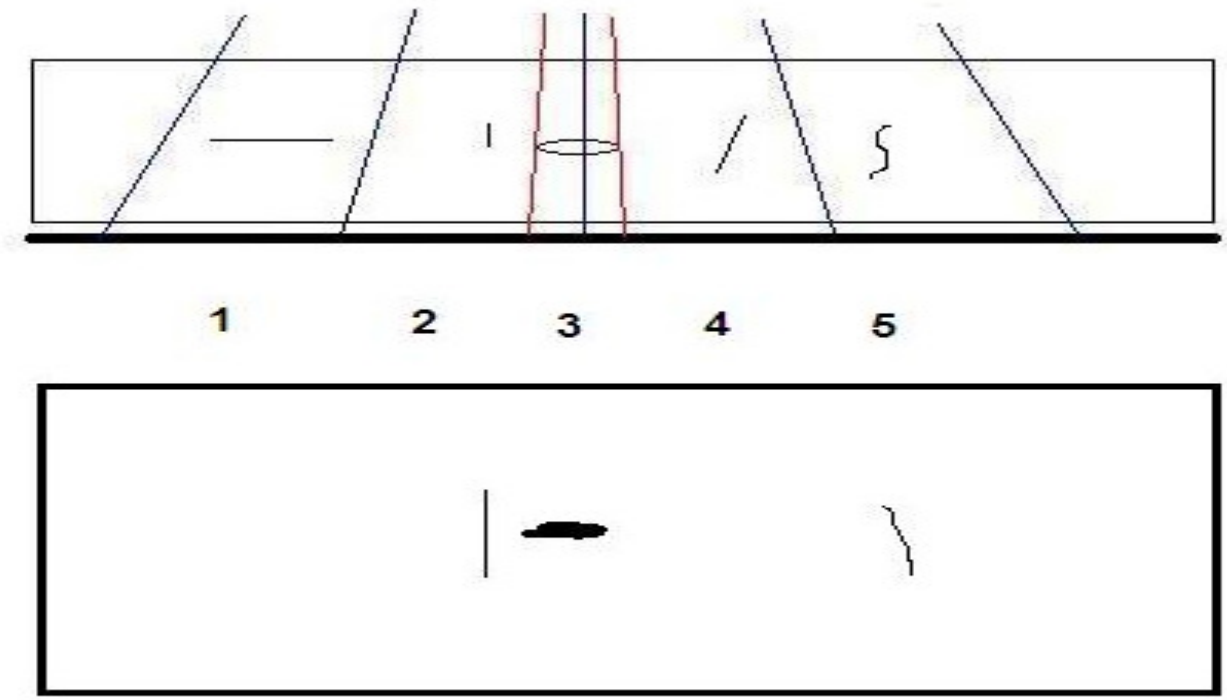
Radiographic Testing Basic Concepts



Radiographic Testing Basic Concepts



Radiographic Testing Basic Concepts



Radiographic Testing Advantages

- Generally Portable
- Surface and subsurface capabilities
- Sensitive to certain defects
- Permanent record
- Clean
- Carbon, stainless, aluminum

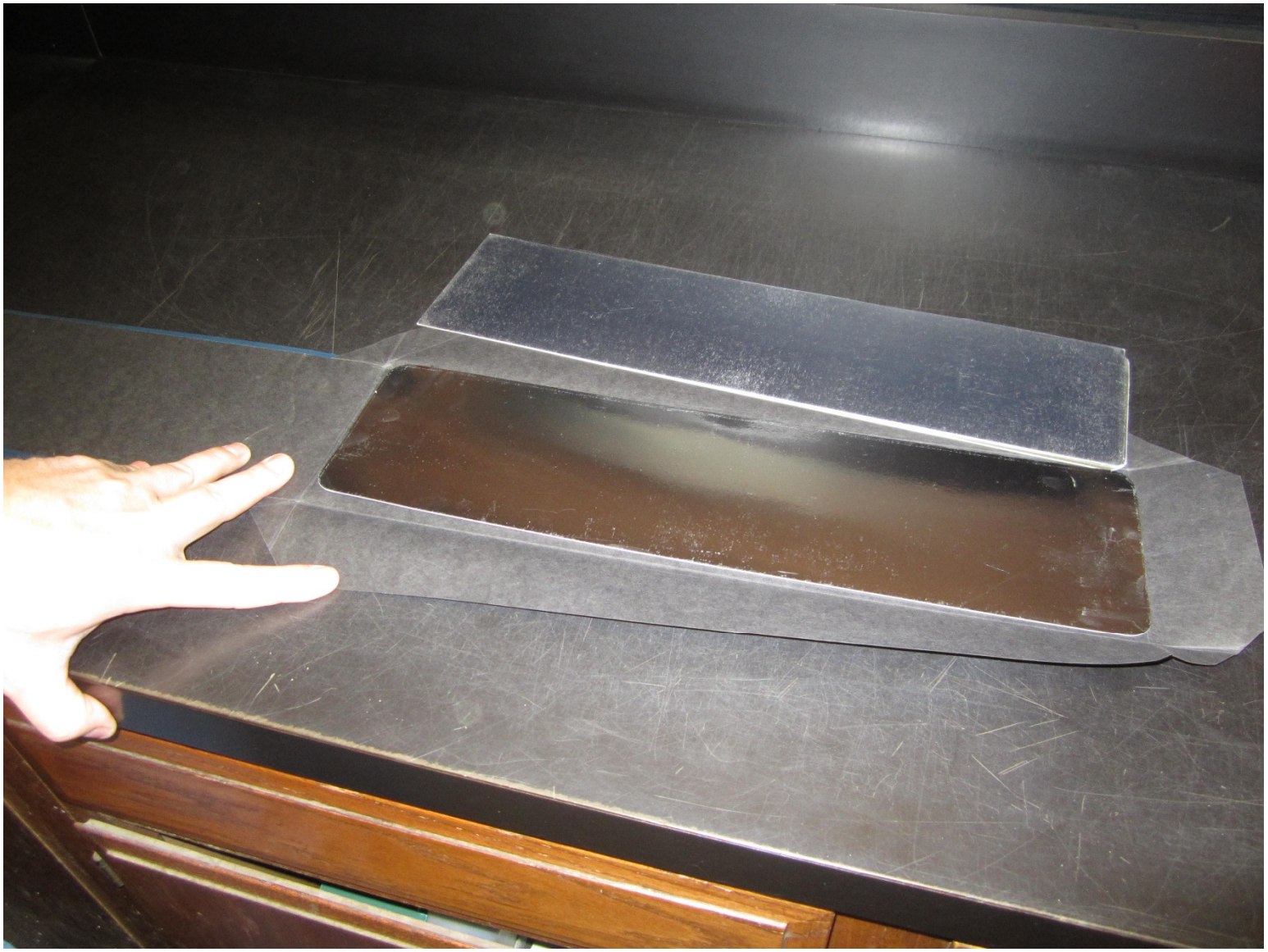
Radiographic Testing Advantages

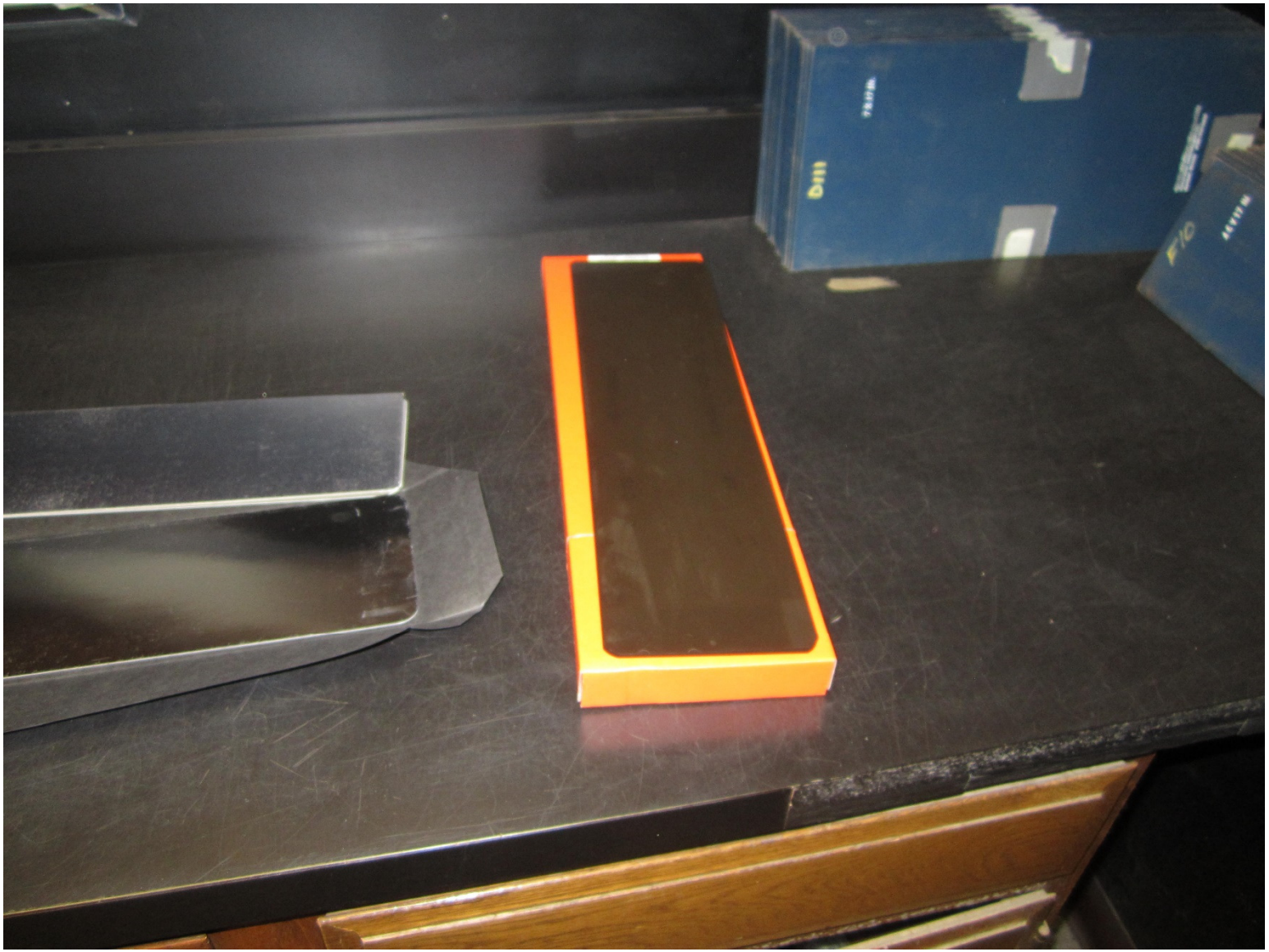
- Expensive
  - equipment, consumables, training, time, maintenance, regulations
- Usually an overnight process
- Dangerous
  - technicians and surrounding personnel
- 2-man crew
- Defect orientation is critical

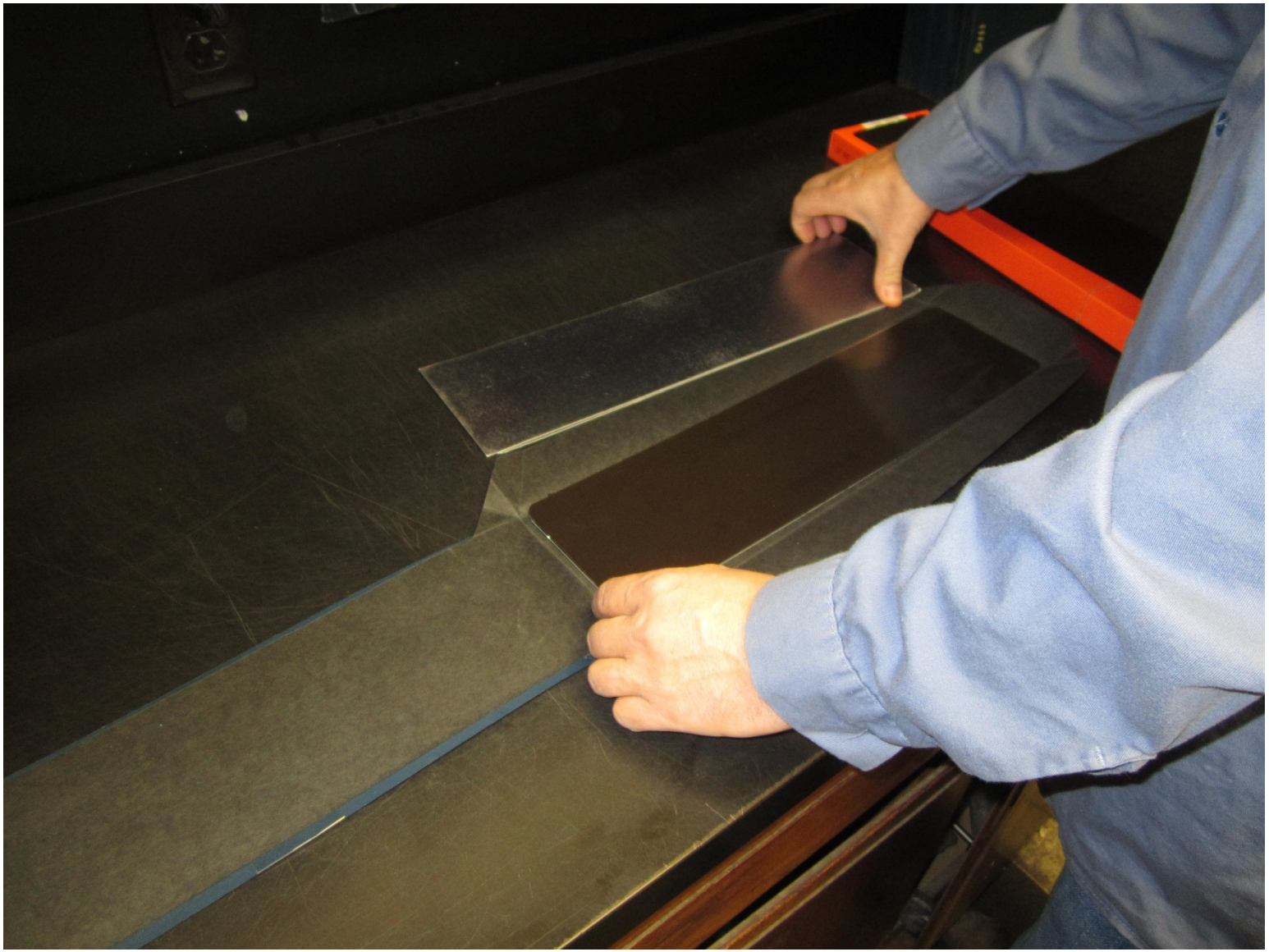
Basic Steps for Film-Type RT

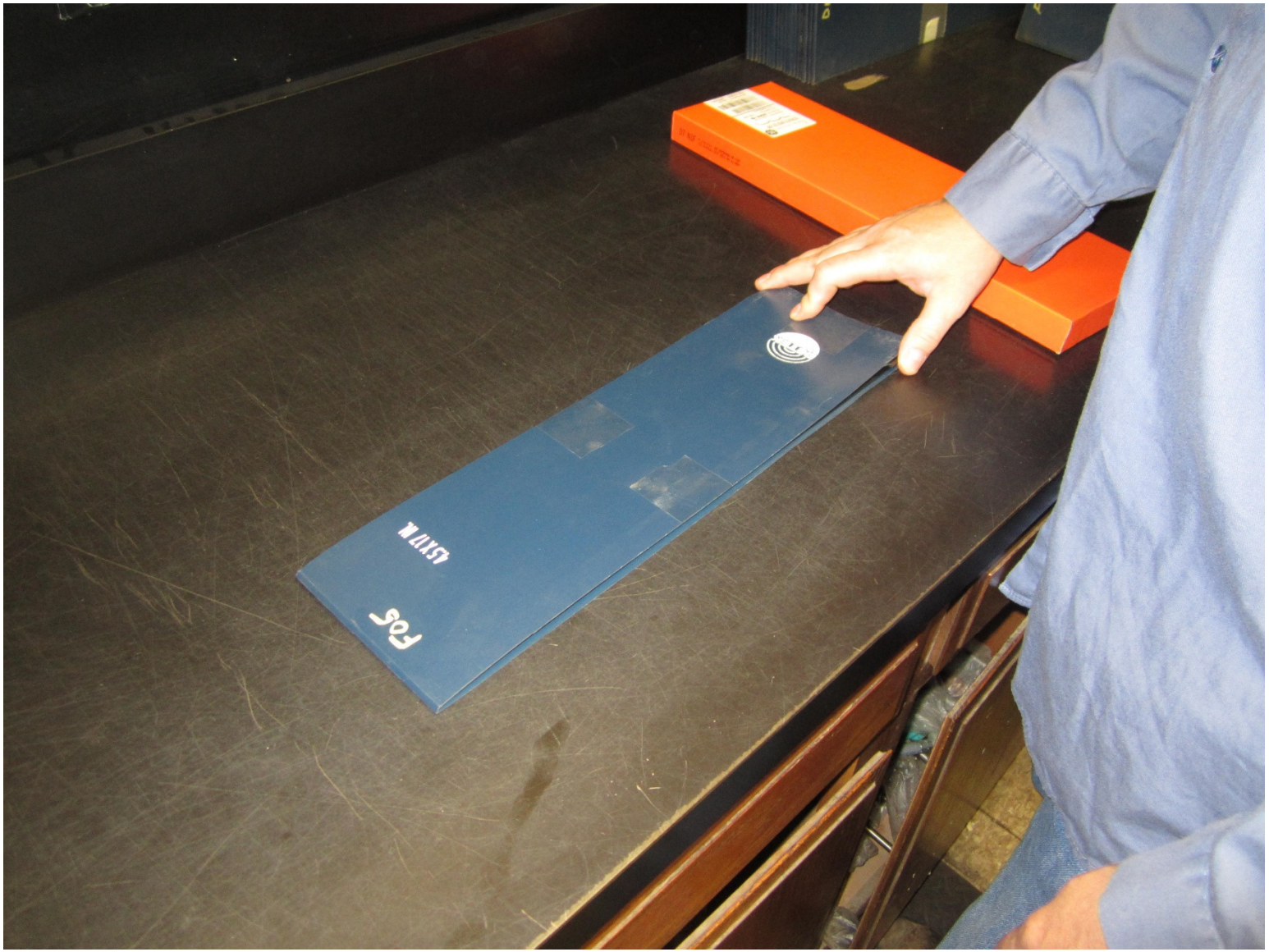
Darkroom

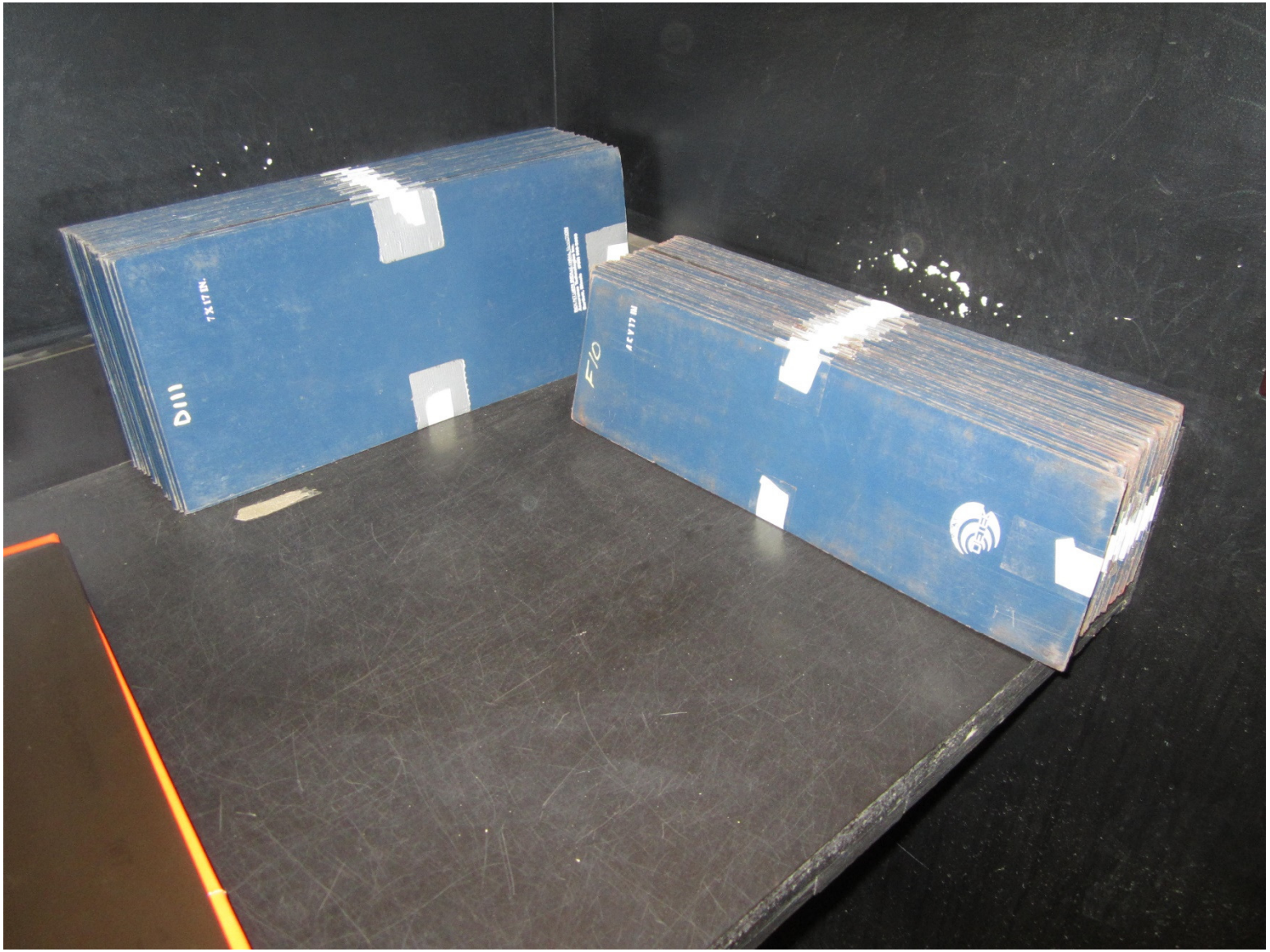
AGFA
Don't shut the processor off.
Leave on to allow water to
circulate. This should help with
the algae problem.
Thanks,
Dave C.




Dell
F10




FOS
ASTRO M

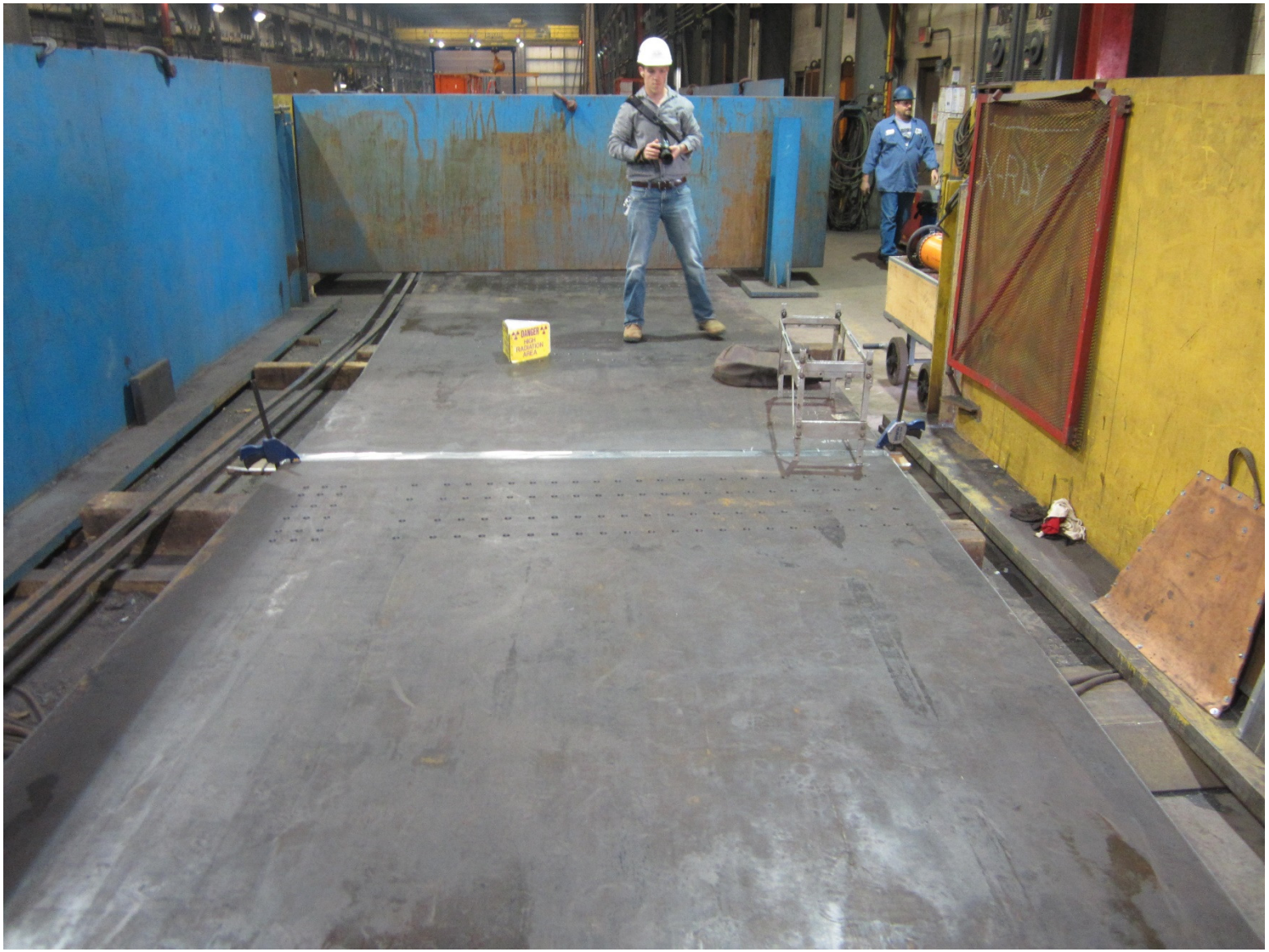

7 X 17 IN.
D111
F10

IP ADRESS 10.3.10.5
JK 219050
MADE IN U.S.A.
Z420

HIGH
Quality Control
RT Film Review Form
HIGH
QC Radiographic Inspection Report
KEKAB

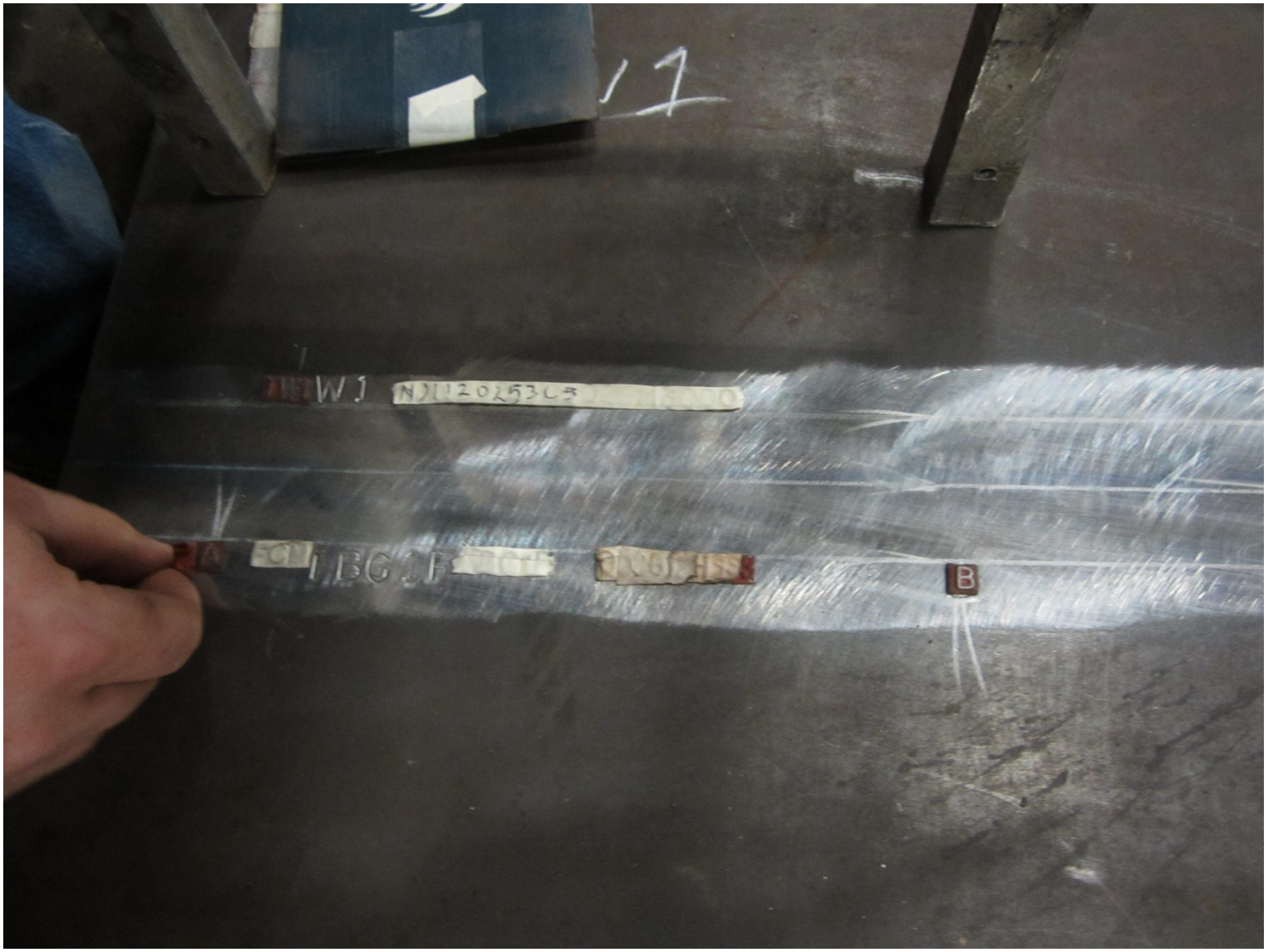
Kimberly-Clark Professional
Kimwipes EX-L
Delicate Task Wipers
Essuie-tout pour tâches délicates
Paños para tareas delicadas
LINTG FREE

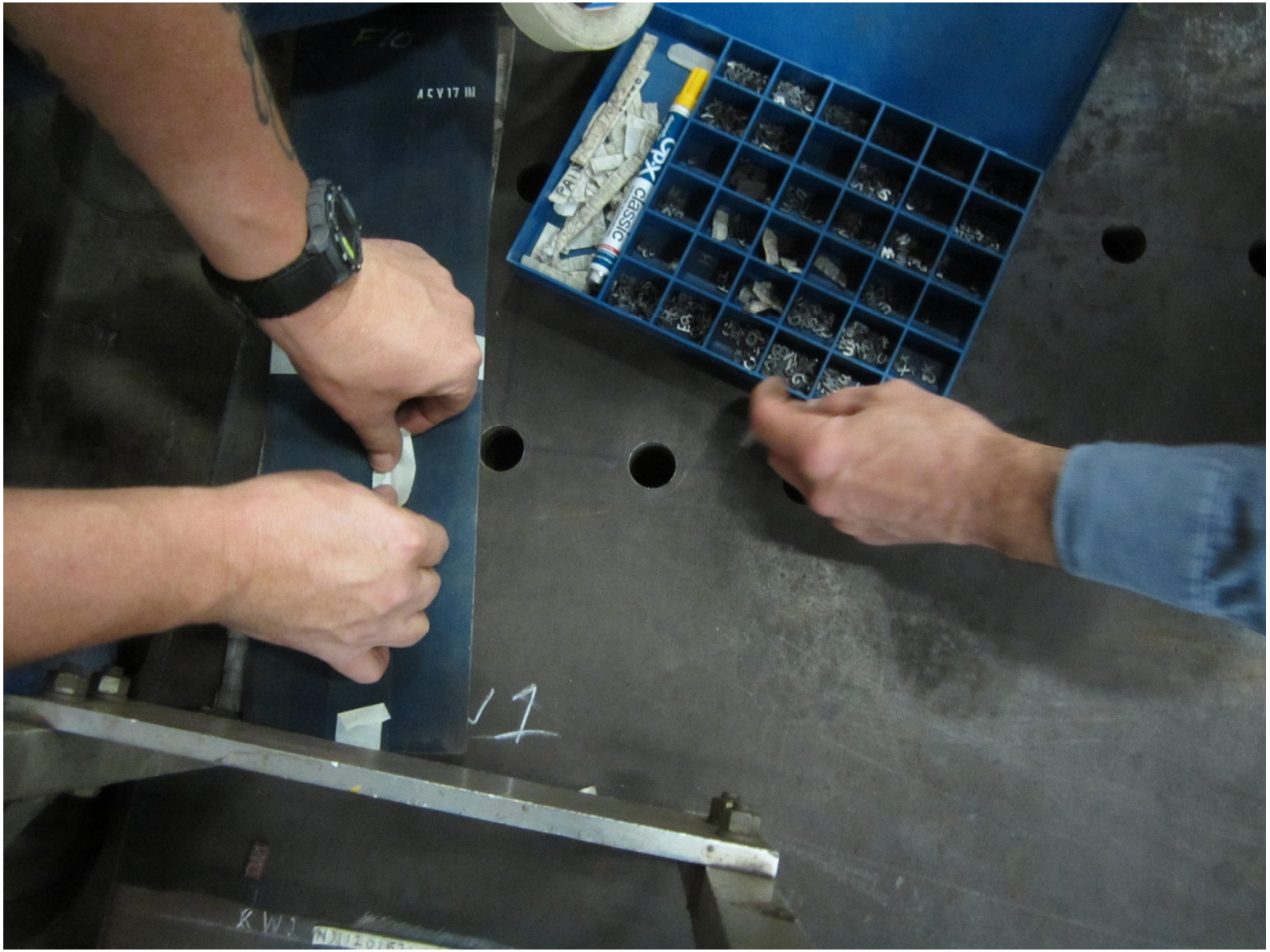
CAUTION
RADIATION AREA
AUTHORIZED
PERSONNEL ONLY
CAUTION
RADIATION AREA
AUTHORIZED
PERSONNEL ONLY
CAUTION
RADIATION AREA
AUTHORIZED
PERSONNEL ONLY
CAUTION
RADIATION AREA
AUTHORIZED
PERSONNEL ONLY
CAUTION
RADIATION AREA
AUTHORIZED
PERSONNEL ONLY
CAUTION
X-RAY
KEEP OUT

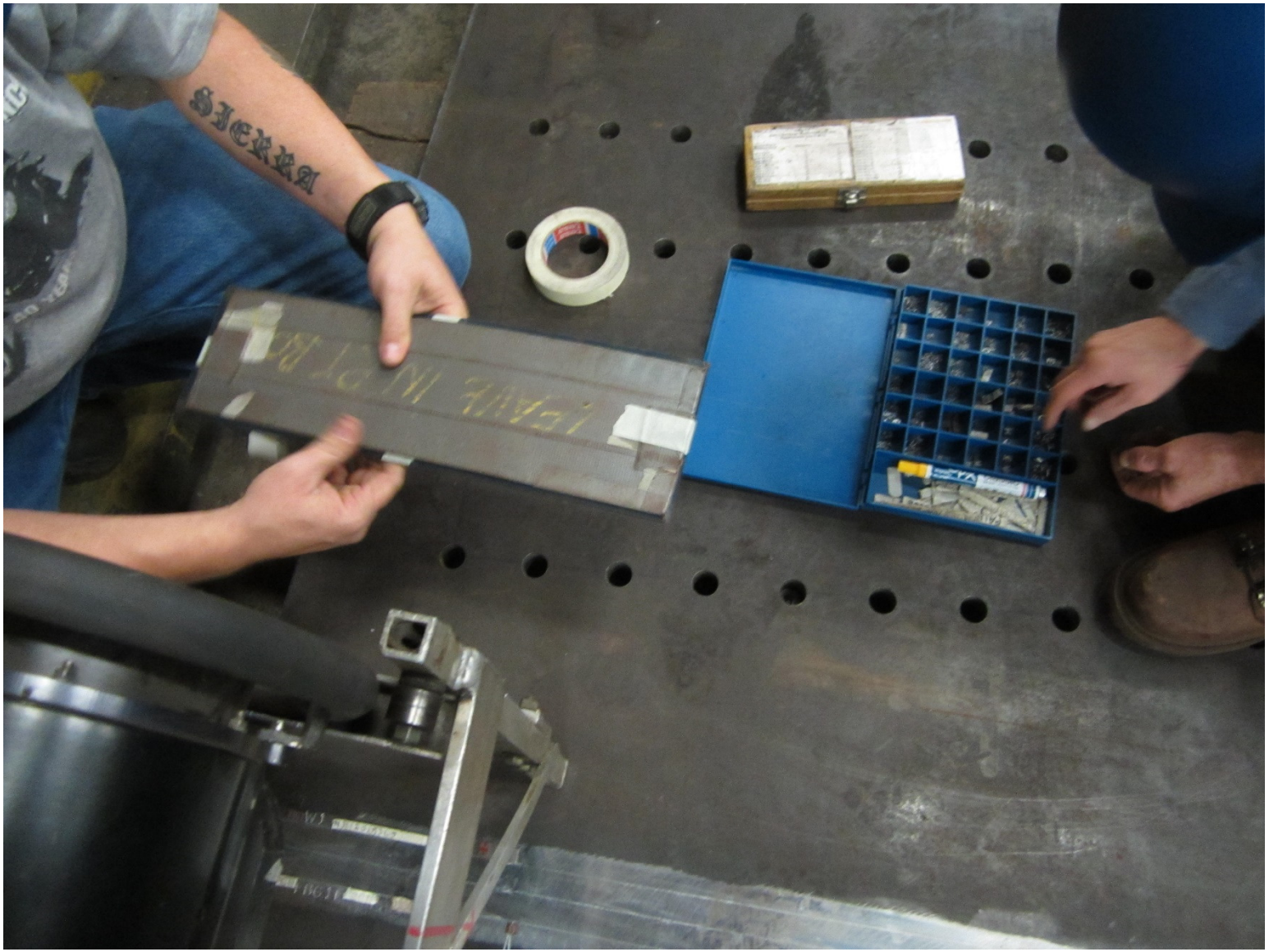

DANGER
HIGH
RADIATION
AREA
X-RAY

IRWIN
QUICK GRIP

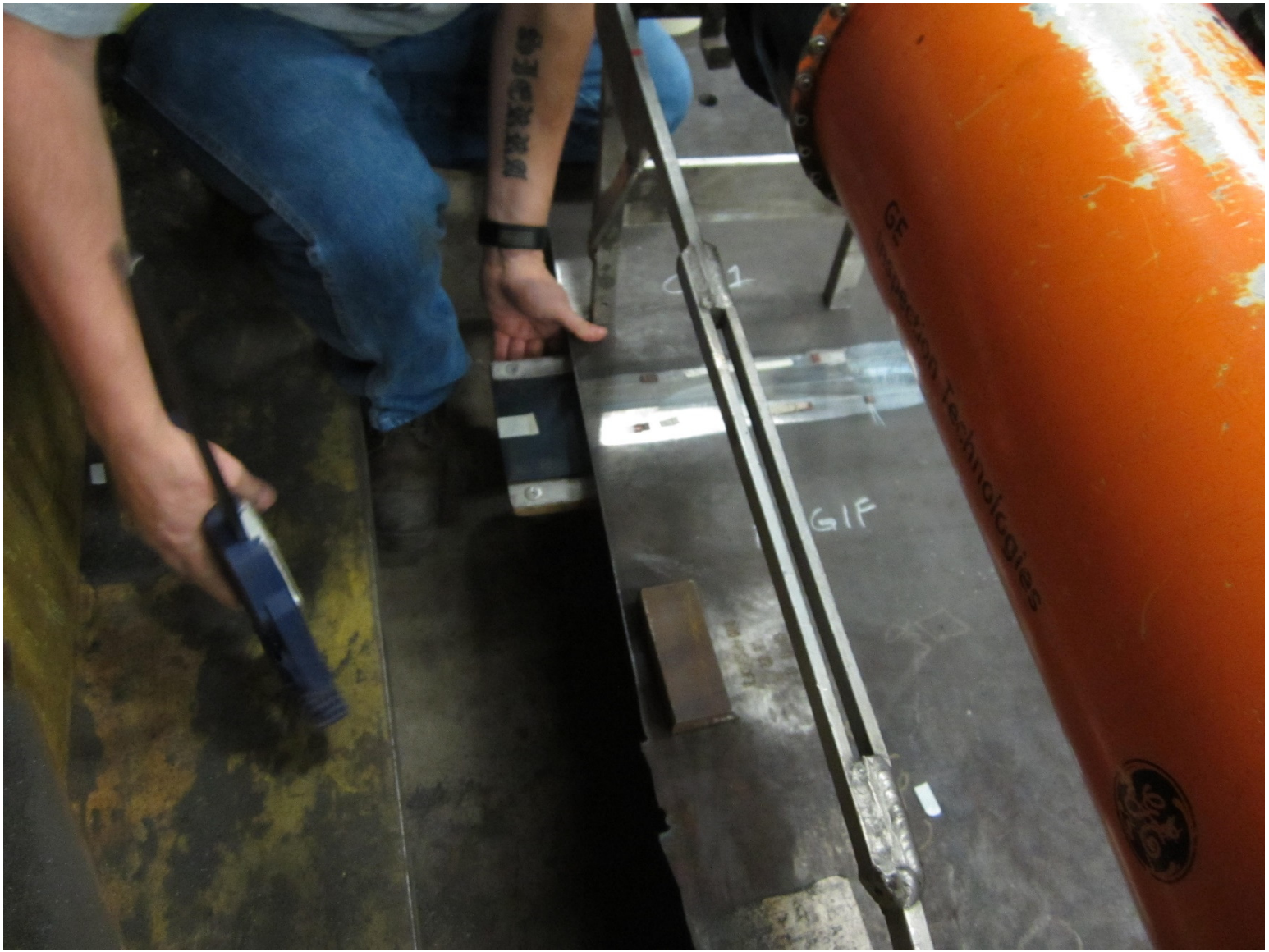
Gox classic


WJ
B


F10
ASV17 III
PAINT
Gpx classic
KW1



RIDER
INSURANCE


GE Transportation Technologies
GIF

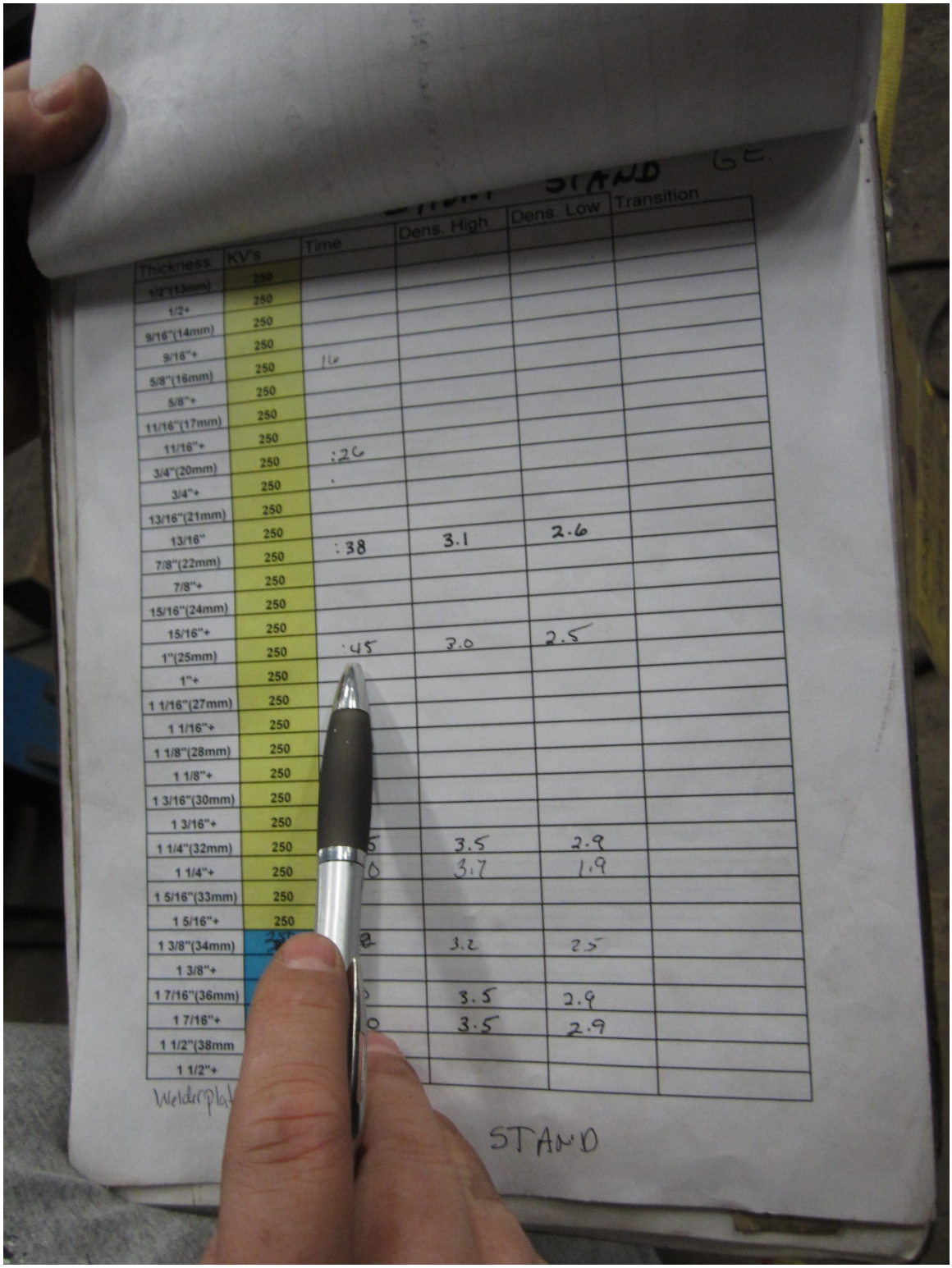
CW
FBG1

DANGER
HIGH
RADIATION
AREA

CAUTION
DO NOT ENTER
KEEP OUT
RADIATION AREA

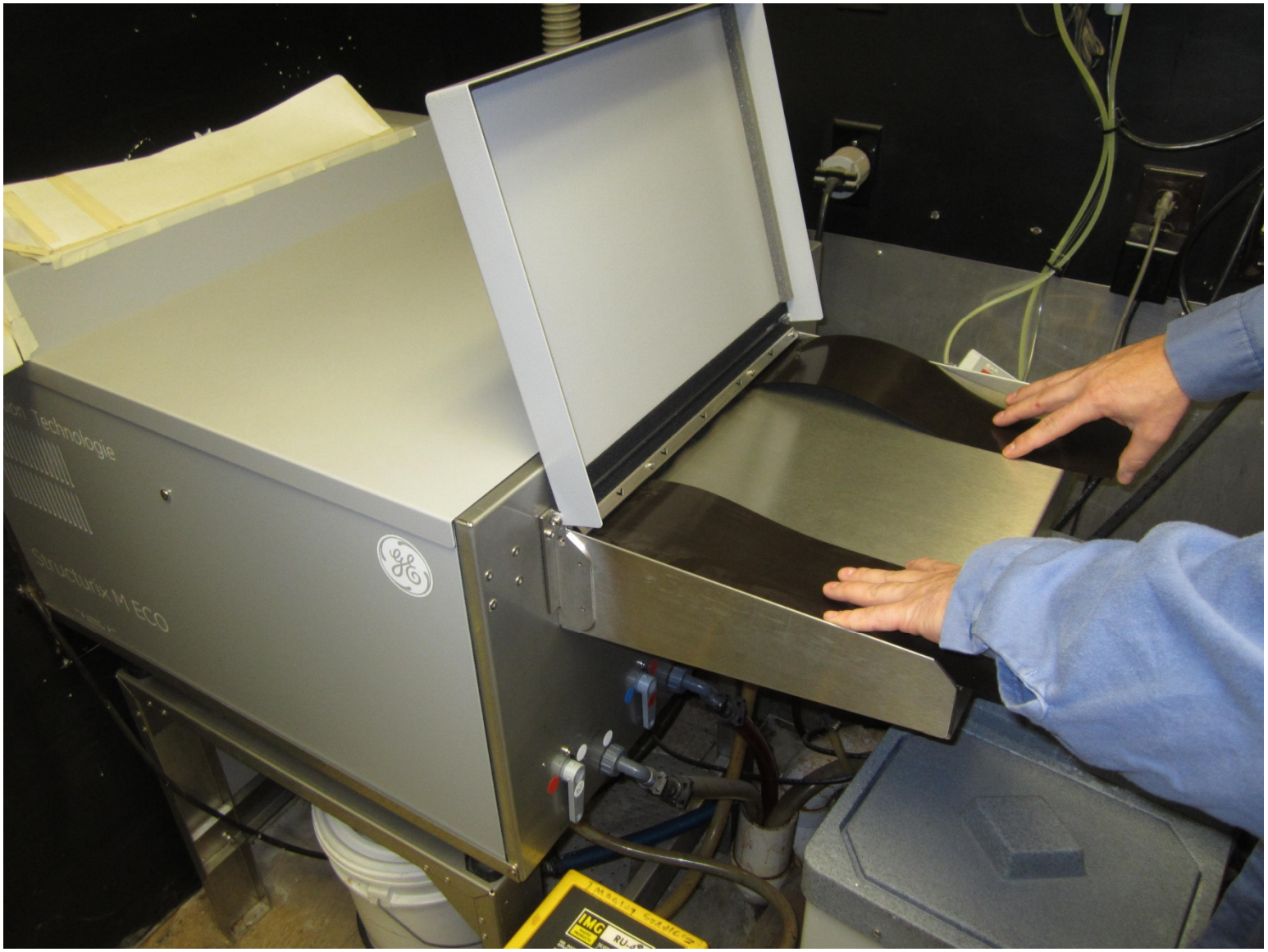
12TONS
X-RAY SHIELD

X-RAY


STAND
Thickness
KV's
Time
Dens. High
Dens. Low
Transition
1/2"(13mm)
250
1/2+
250
9/16"(14mm)
250
9/16"+
250
5/8"(16mm)
250
5/8"+
250
11/16"(17mm)
250
11/16"+
250
3/4"(20mm)
250
3/4"+
250
13/16"(21mm)
250
13/16"
250
7/8"(22mm)
250
7/8"+
250
15/16"(24mm)
250
15/16"+
250
1"(25mm)
250
1"+
250
1 1/16"(27mm)
250
1 1/16"+
250
1 1/8"(28mm)
250
1 1/8"+
250
1 3/16"(30mm)
250
1 3/16"+
250
1 1/4"(32mm)
250
1 1/4"+
250
1 5/16"(33mm)
250
1 5/16"+
250
1 3/8"(34mm)
1 3/8"+
1 7/16"(36mm)
1 7/16"+
1 1/2"(38mm
1 1/2"+
:26
:38
3.1
2.6
:45
3.0
2.5
3.5
2.9
3.7
1.9
3.2
2.5
3.5
2.9
3.5
2.9
STAND

Darkroom

THIS SIDE UP
CORROSIVE
8
G 135 S
AGFA
G 135 S
AGFA


Technologie
Structurix M ECO
IMG

Timexon

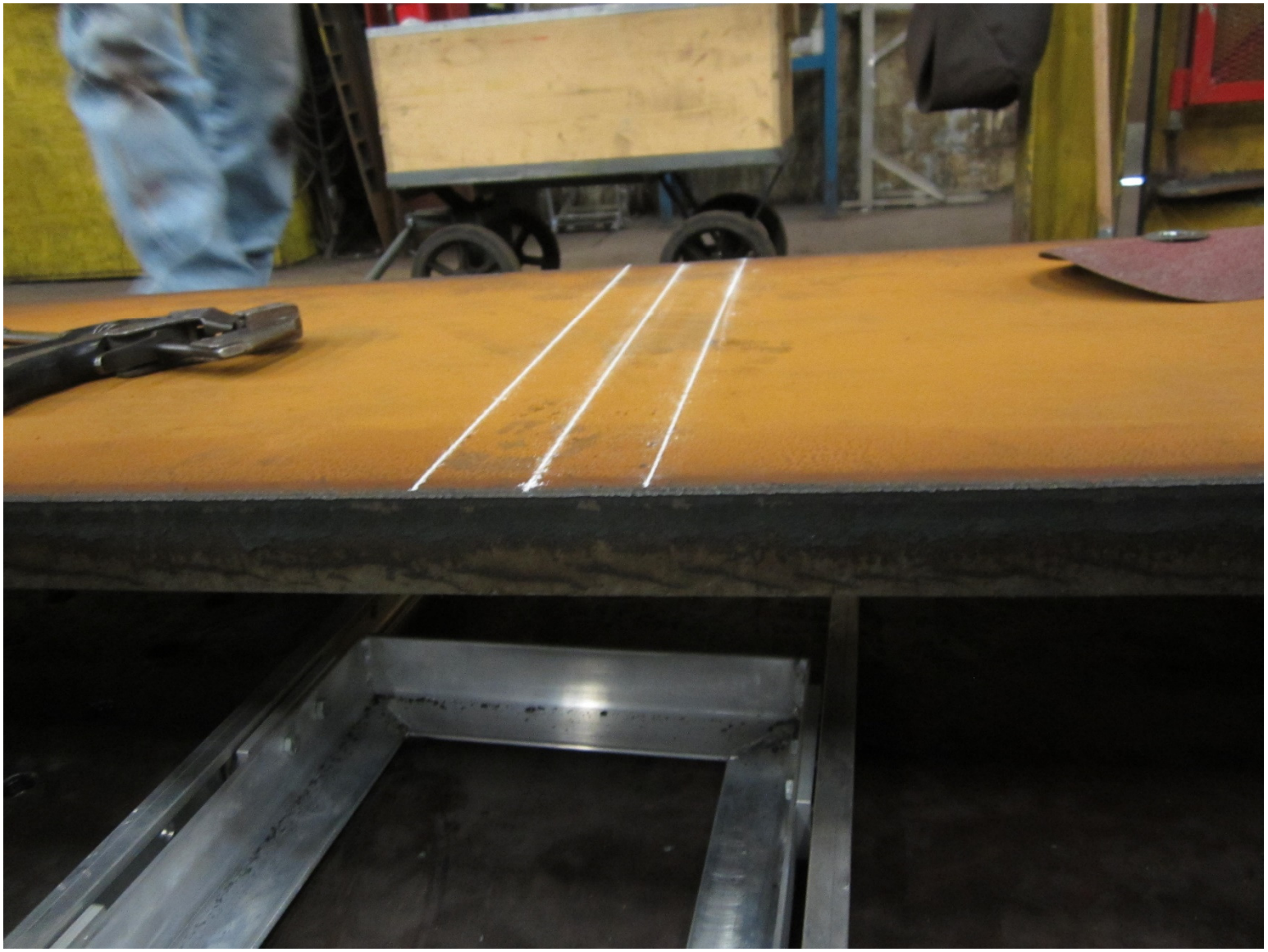
OH1100163C-6
PA 122
NY 107-3
CT 1100404A-1
NY-068A-1
PA1110170A-5
PA1110170-5

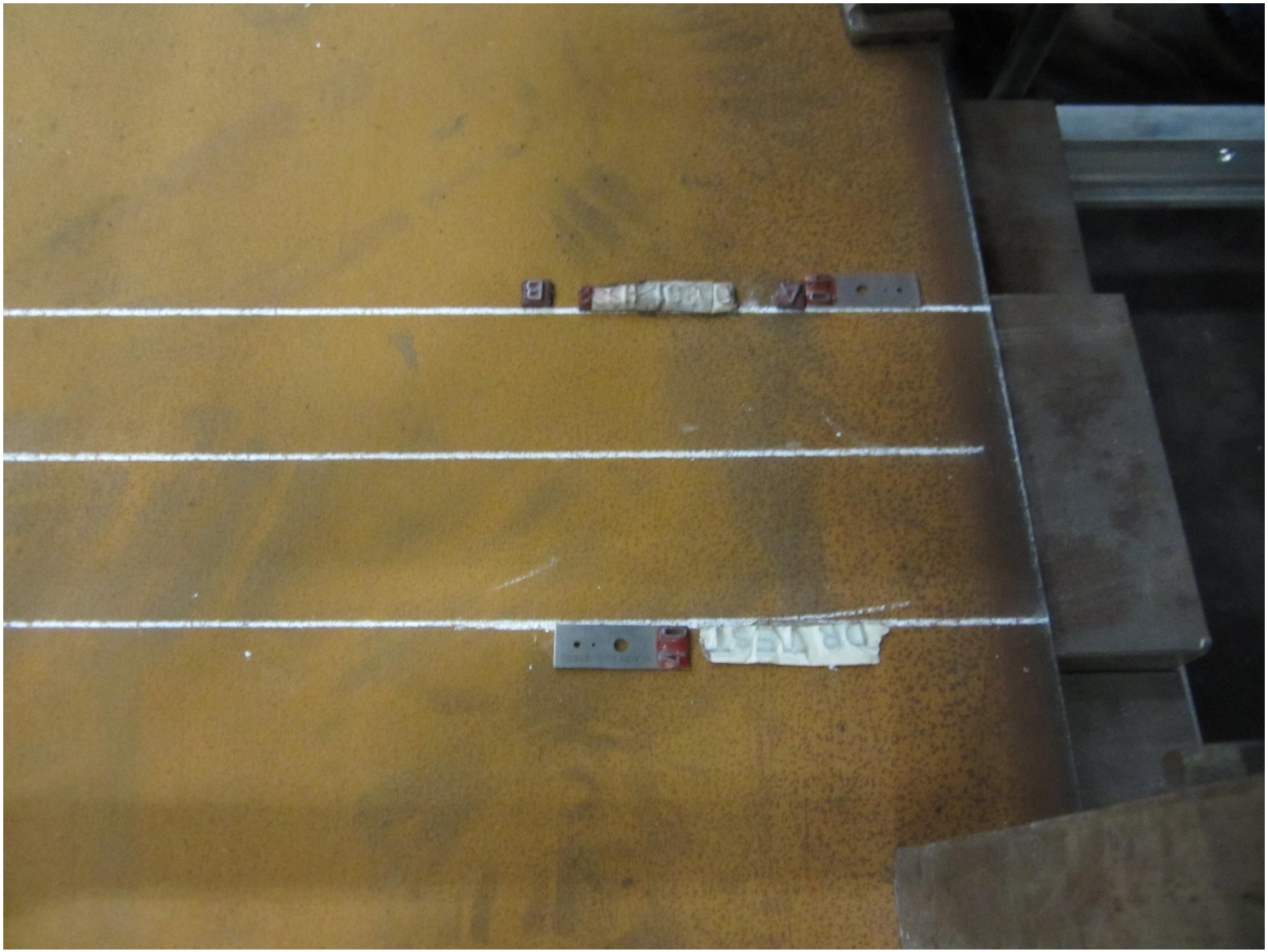
START
CAL
SELECT
RT 120
TECHKON
DETEK, INC.
800-638-0553

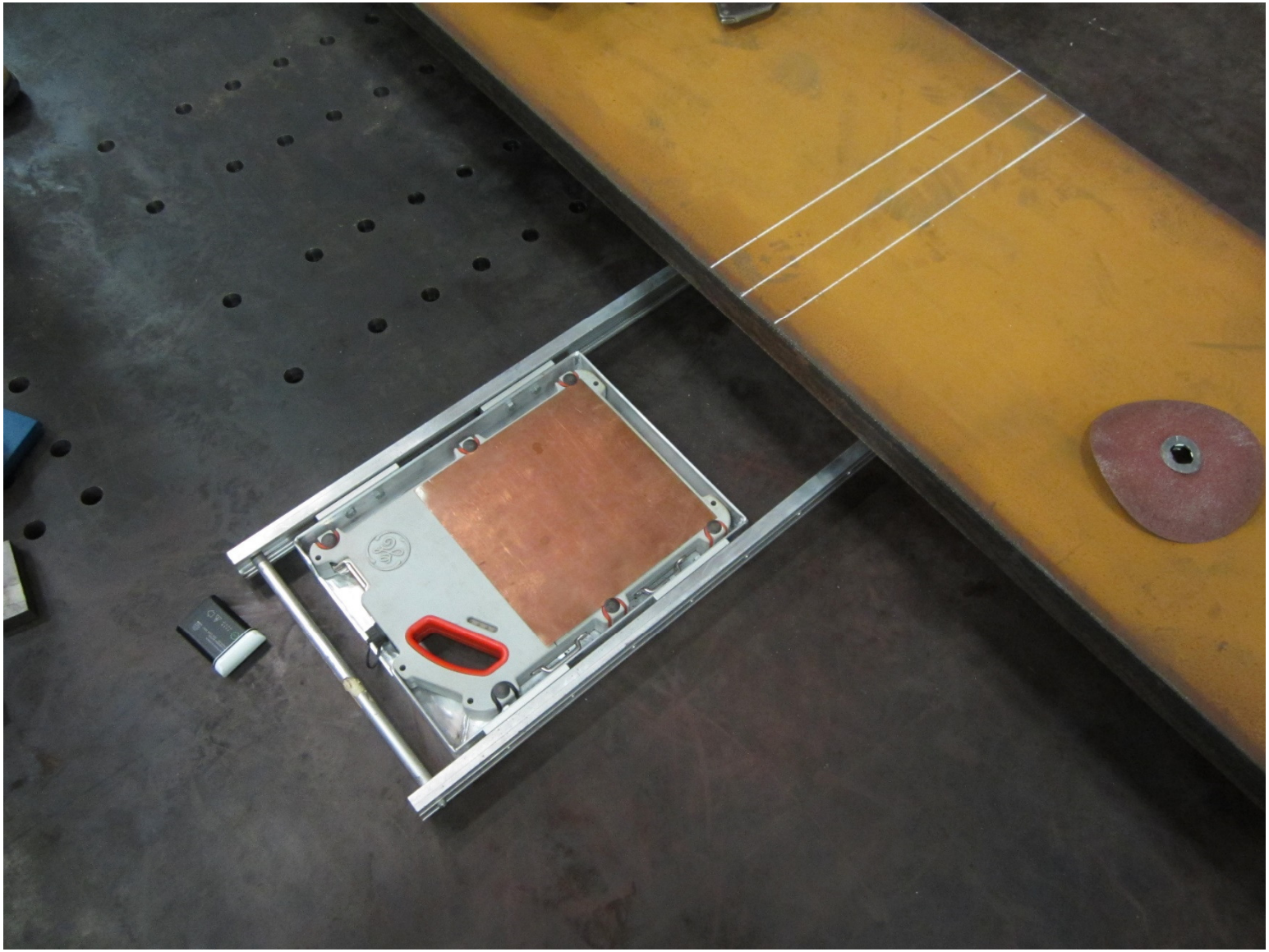
1 7
TW1
NY1110152F-6D261771
1 7
B
02 26 13HSSI3
A
G4B

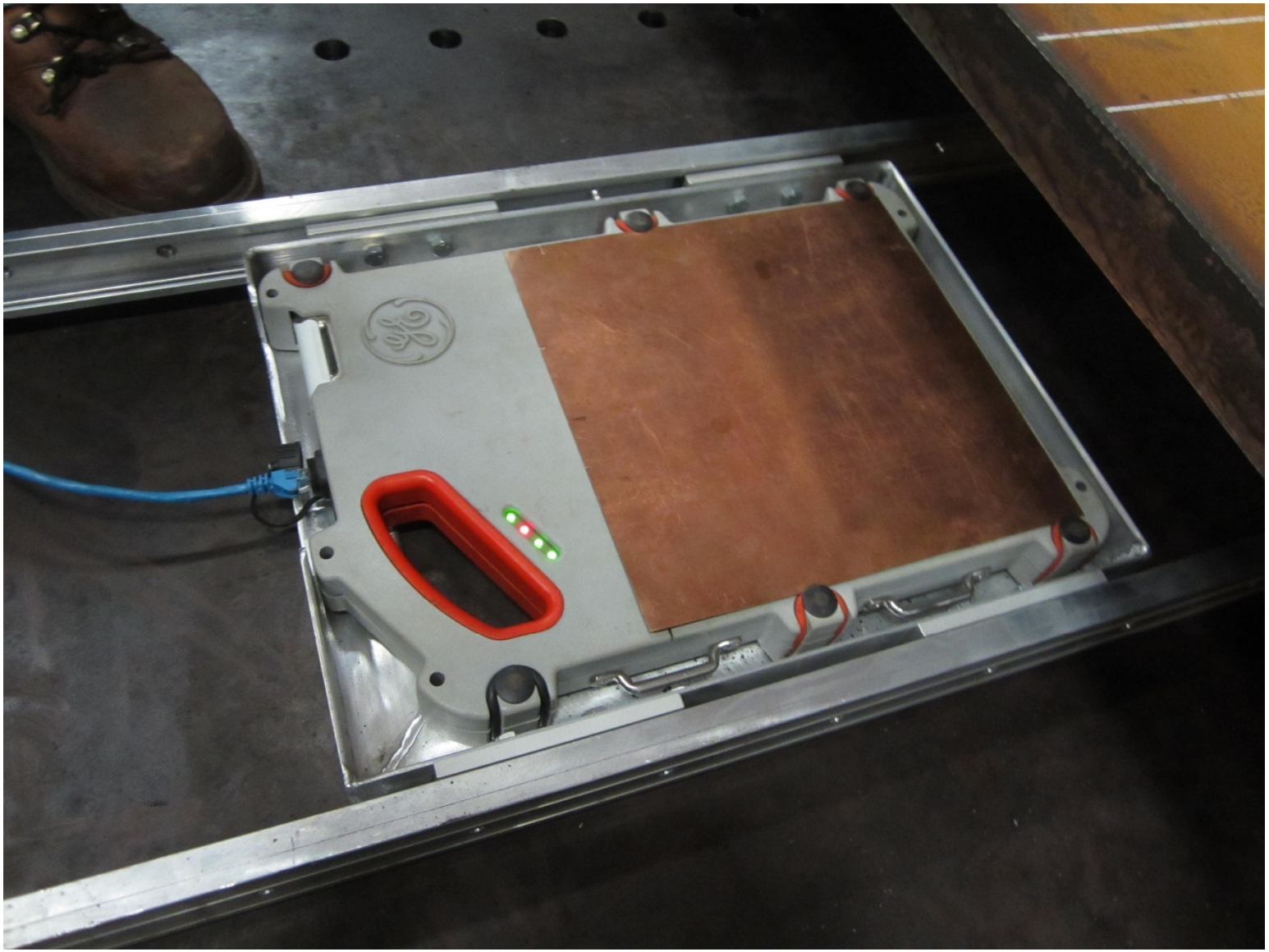
Basic Steps – Digital Radiography

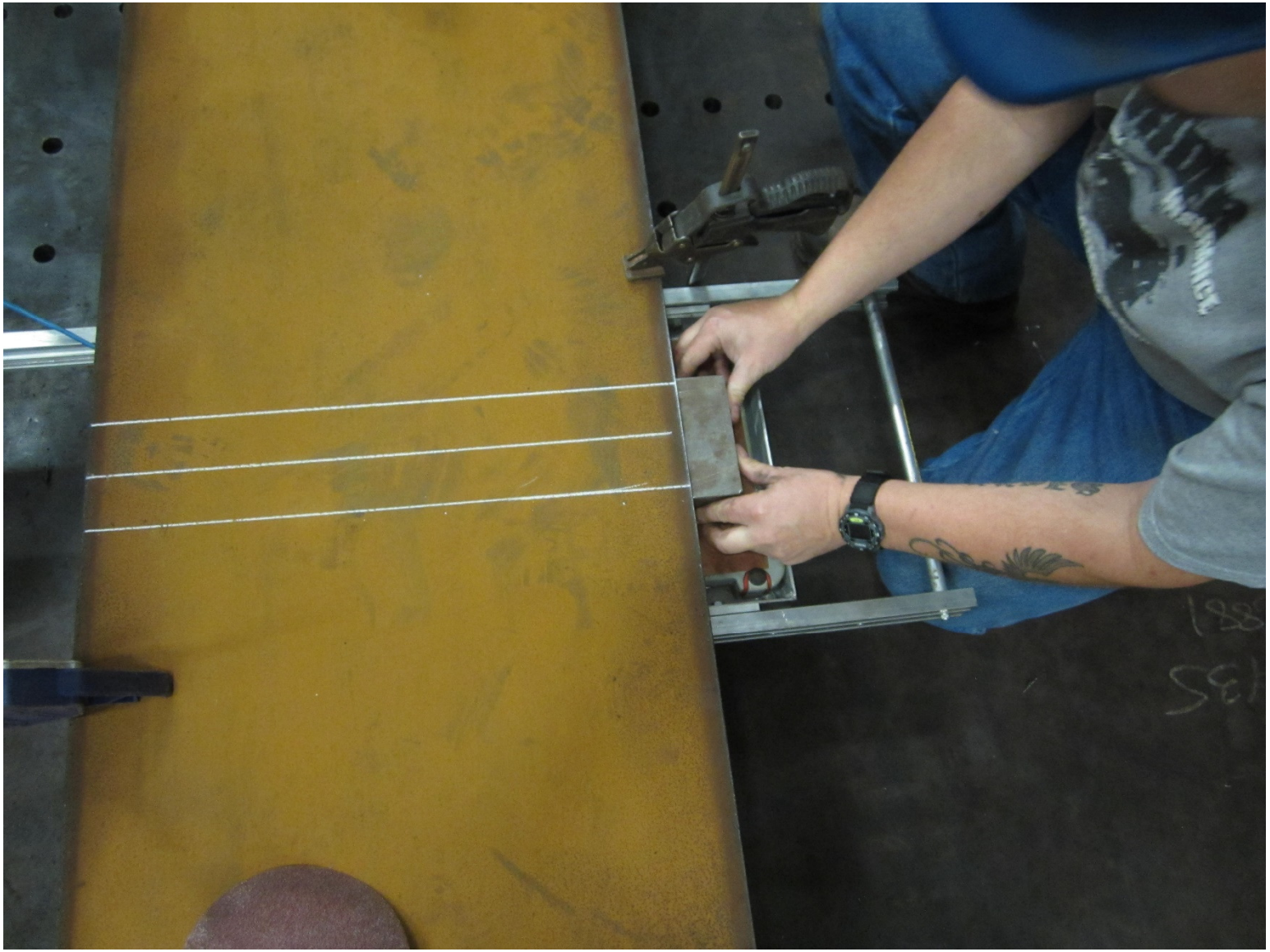
GE
Inspection Technologies
DANGER
HIGH
RADIATION
AREA

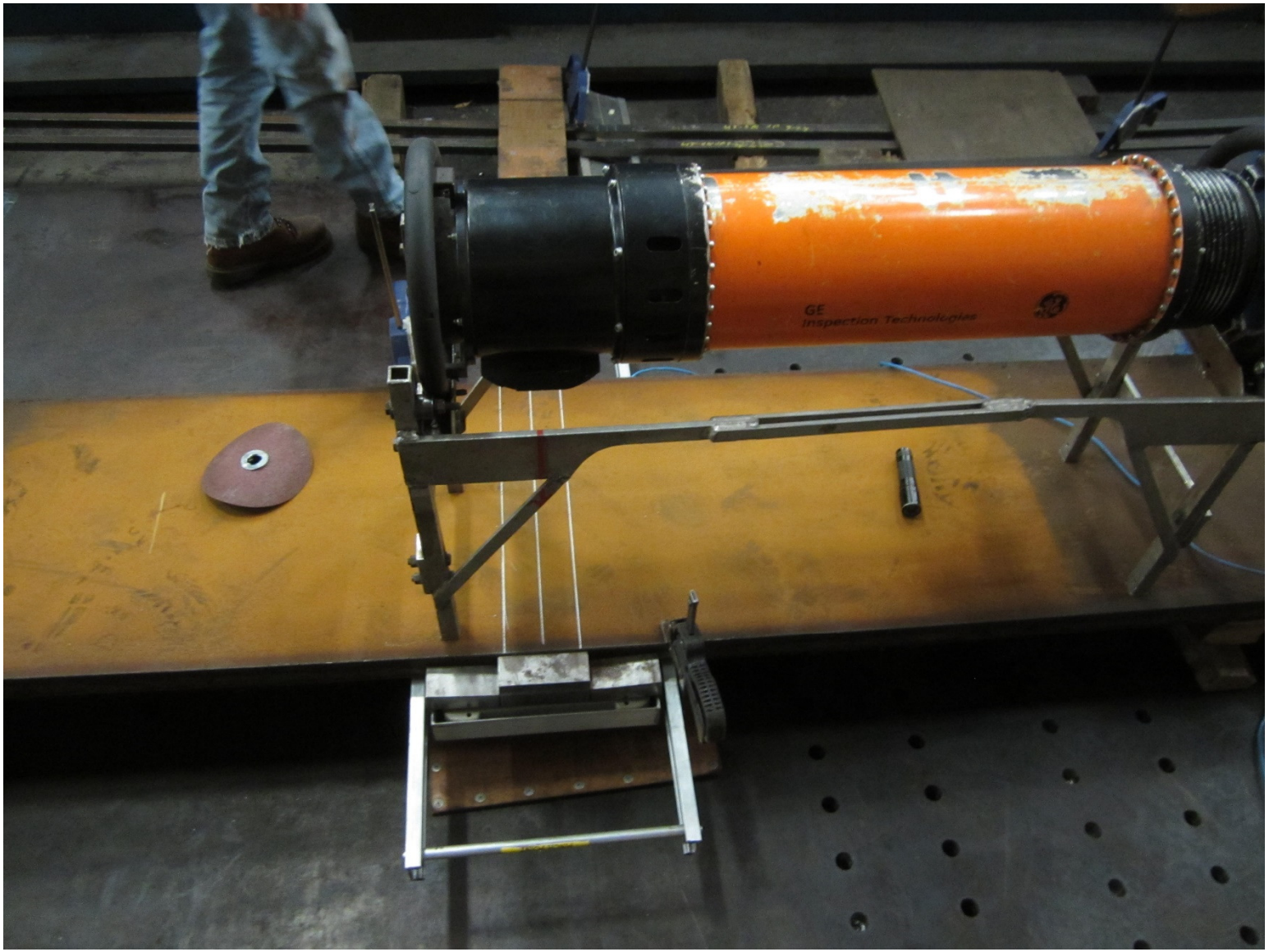


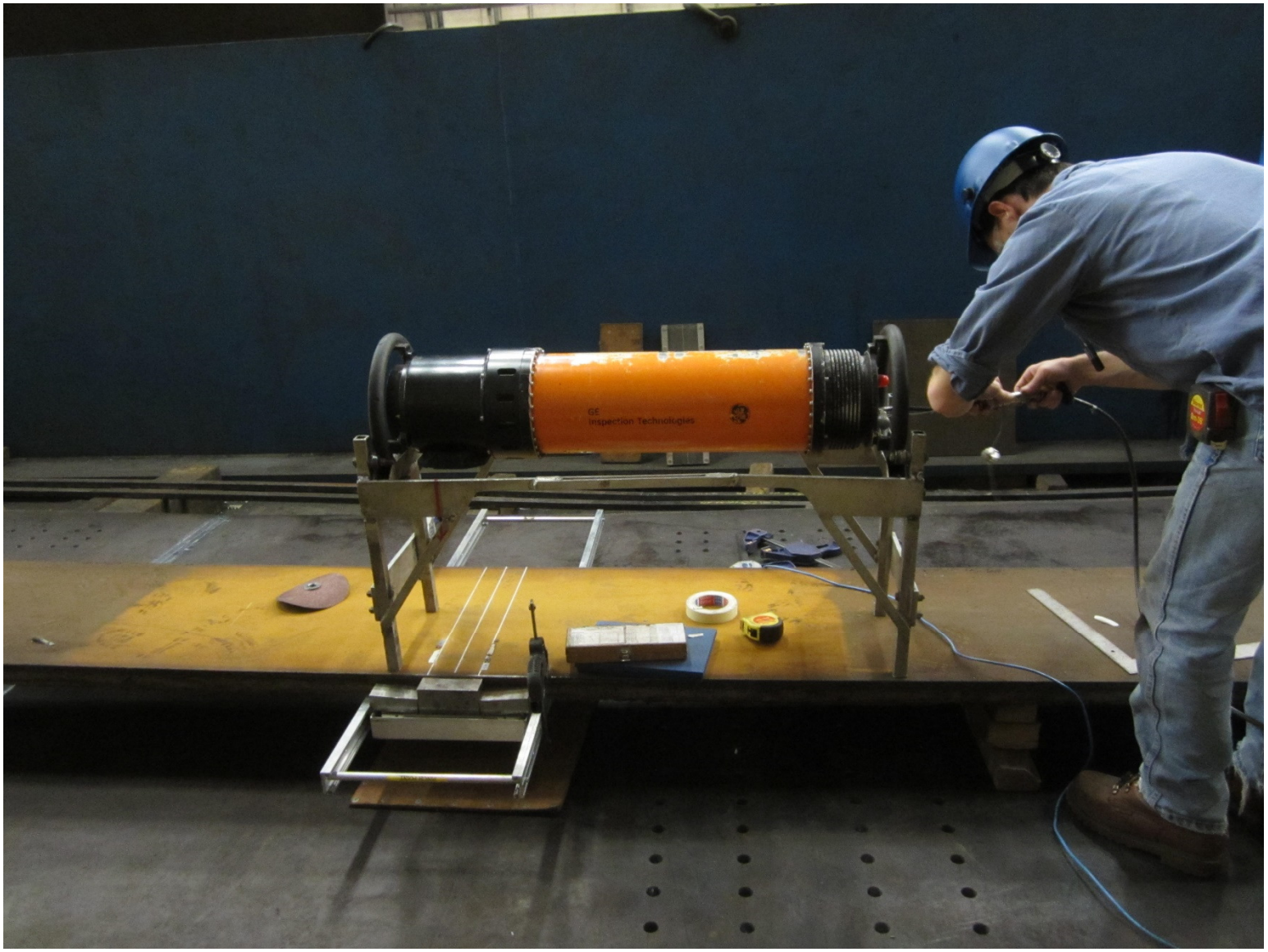

B
A
DR TEST





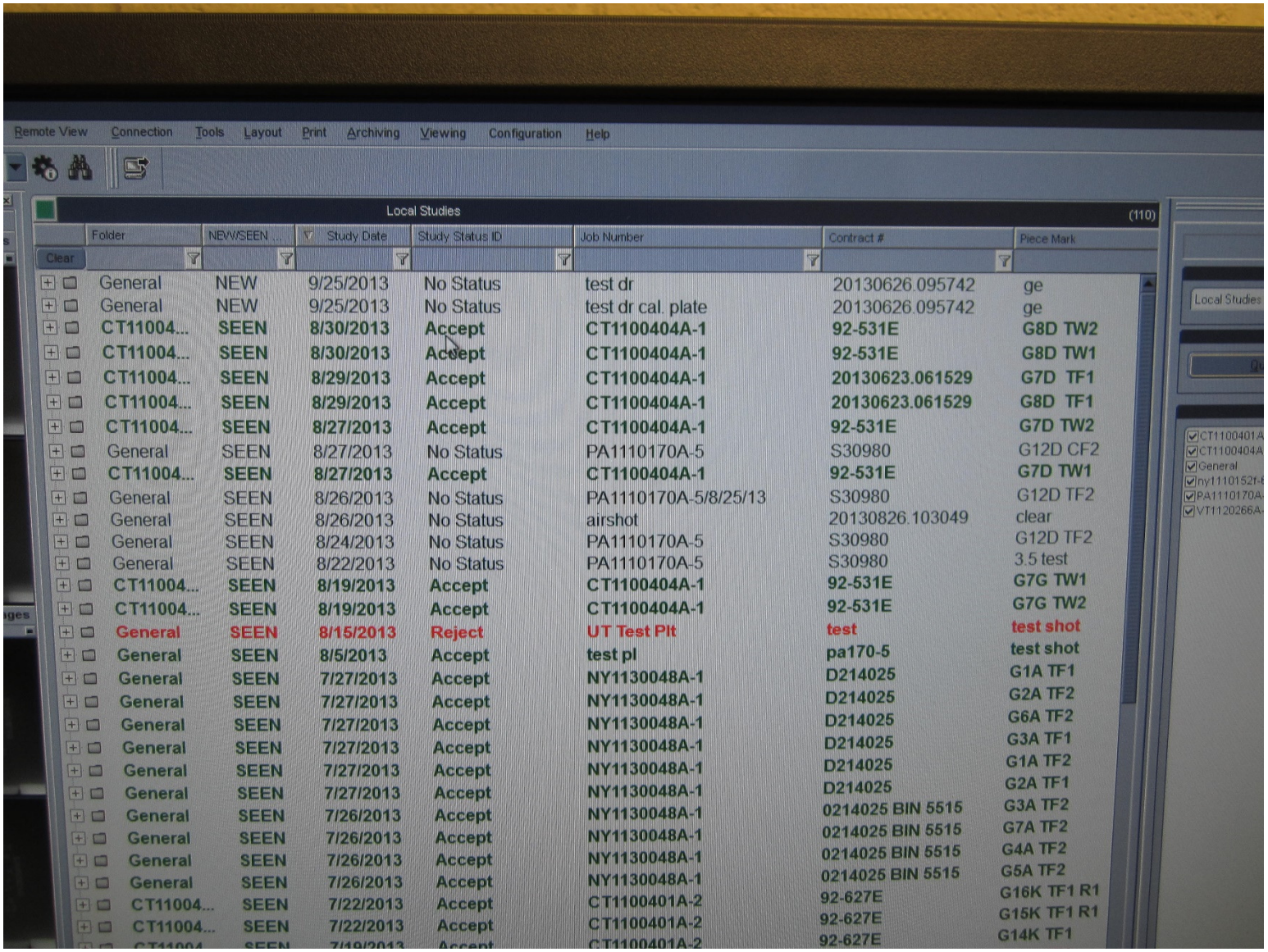



GE
Inspection Technologies


GE
Inspection Technologies

Starting Windows

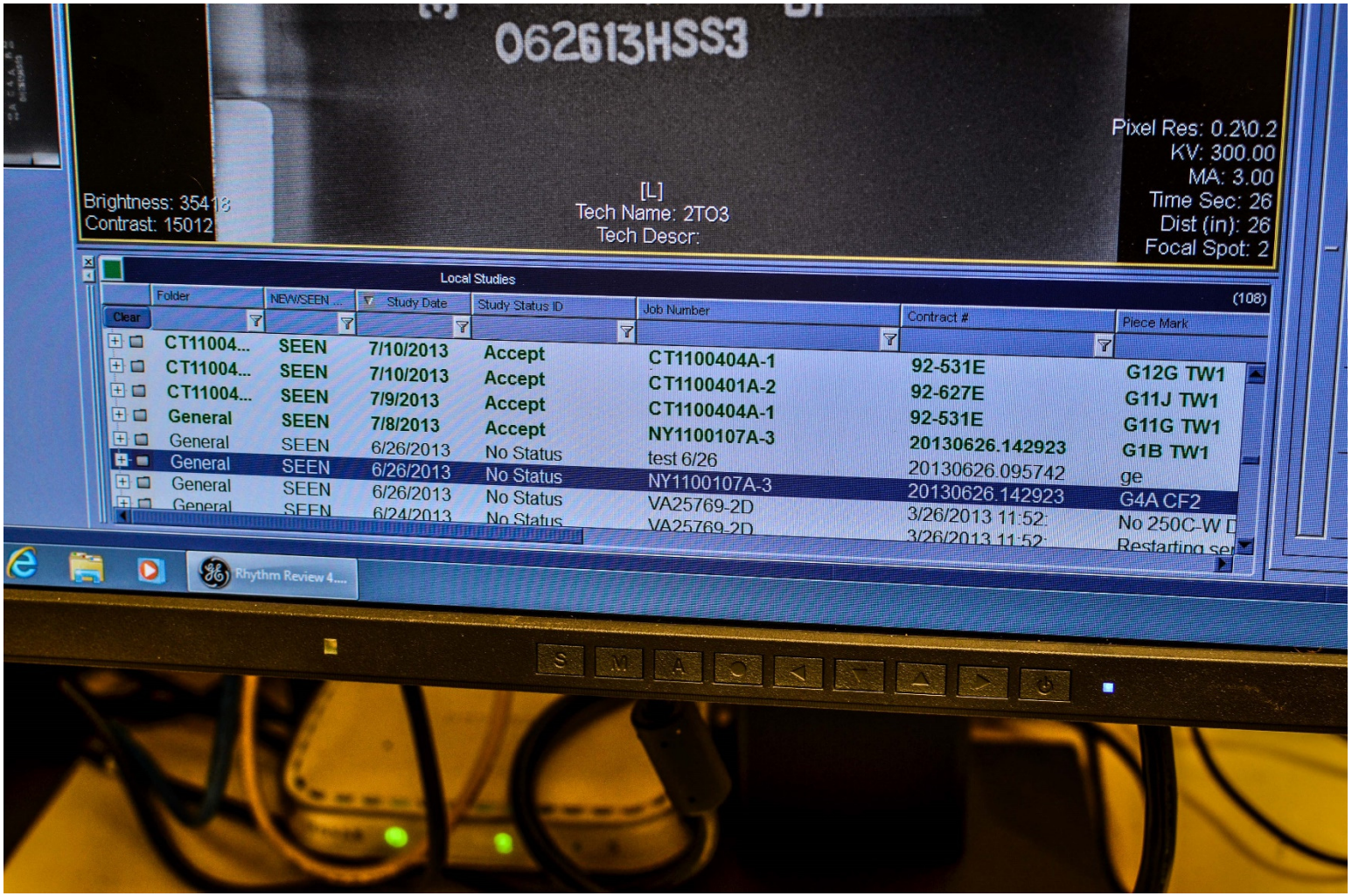
iP ADRESS 10.3.10.5
Quality Control Dosimeter/Survey Meter Log
Quality Control Dosimeter/Survey Meter Log
Z420



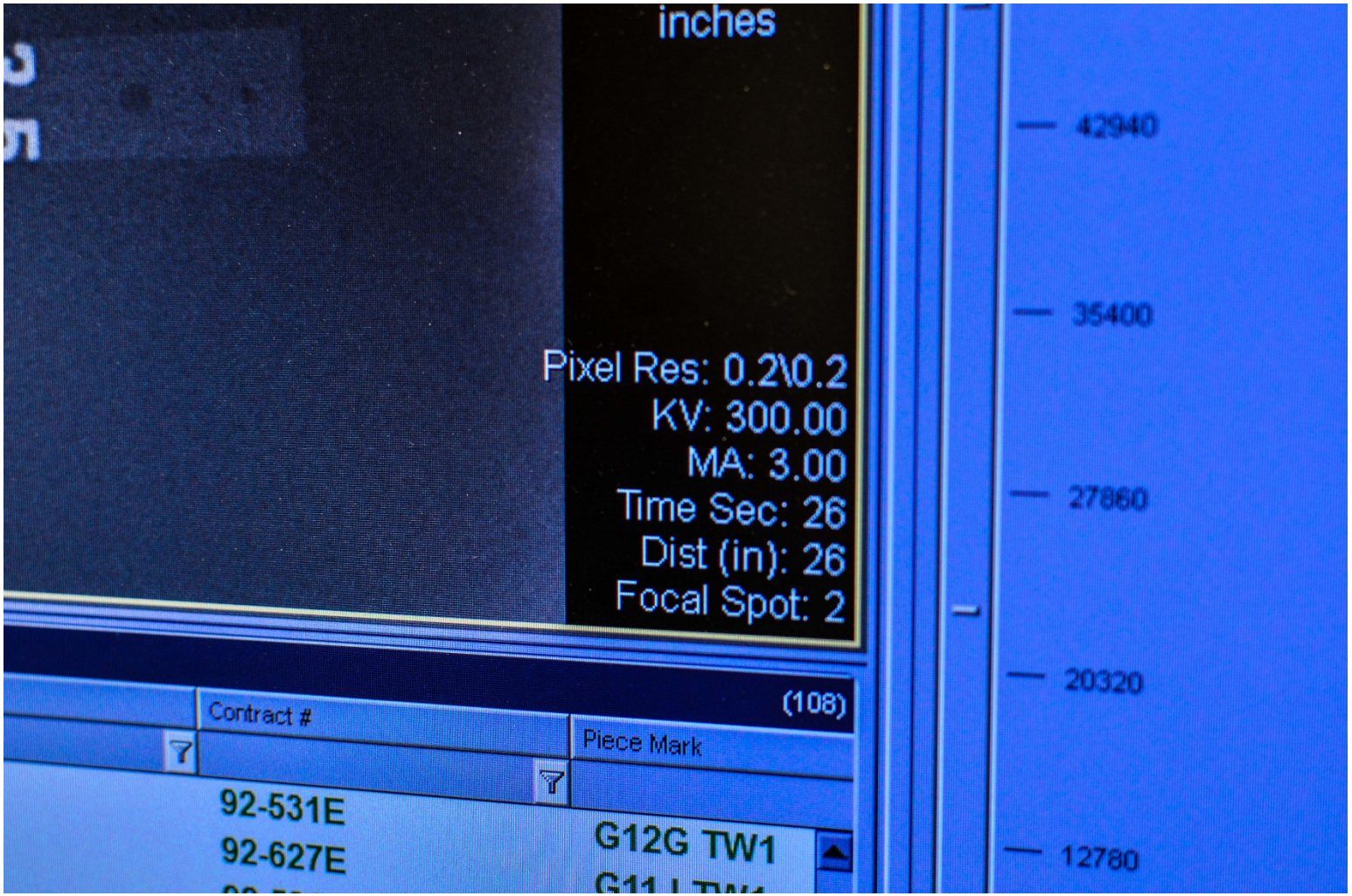
Remote View Connection Tools Layout Print Archiving Viewing Configuration Help

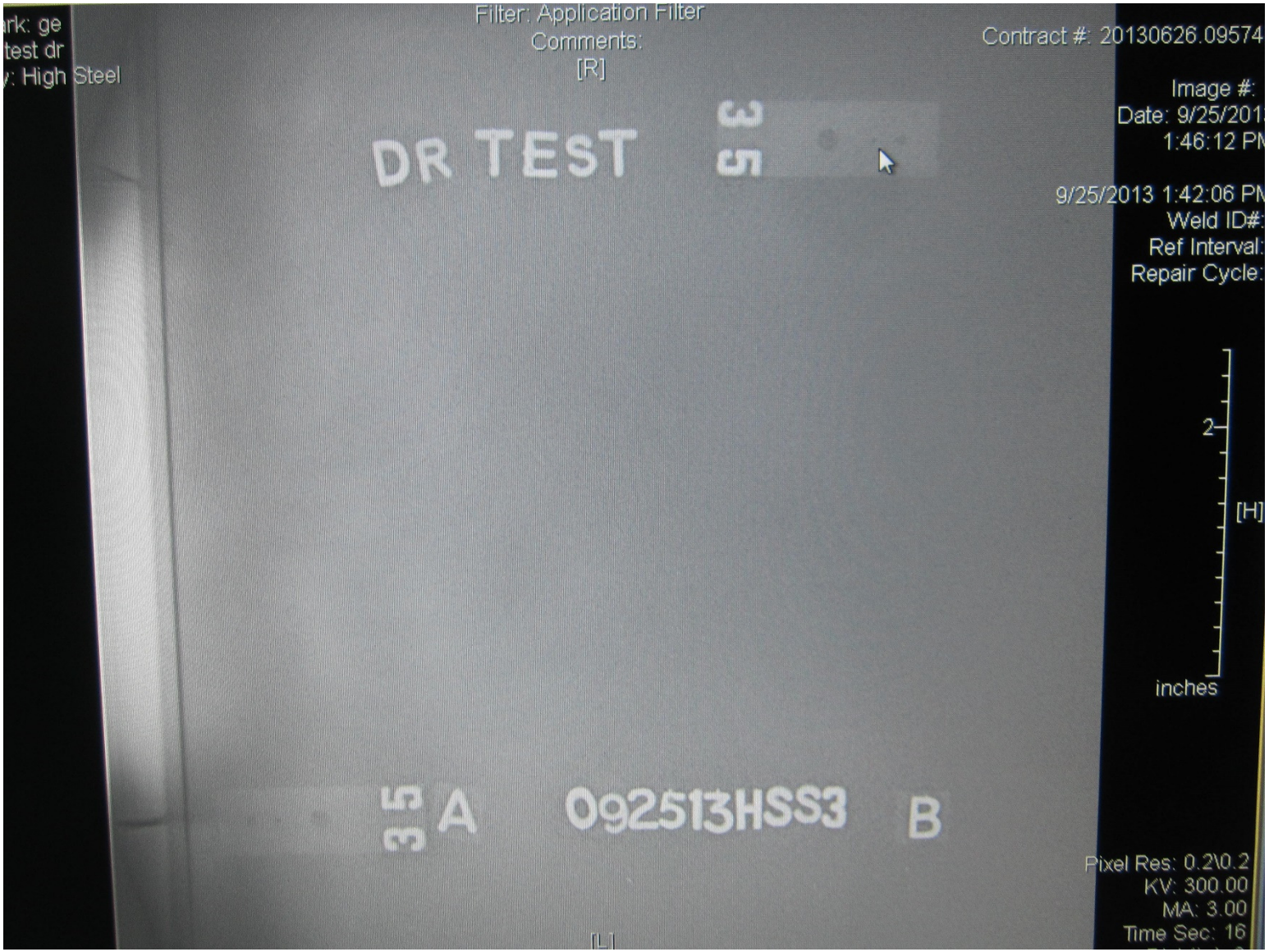
Local Studies (110)

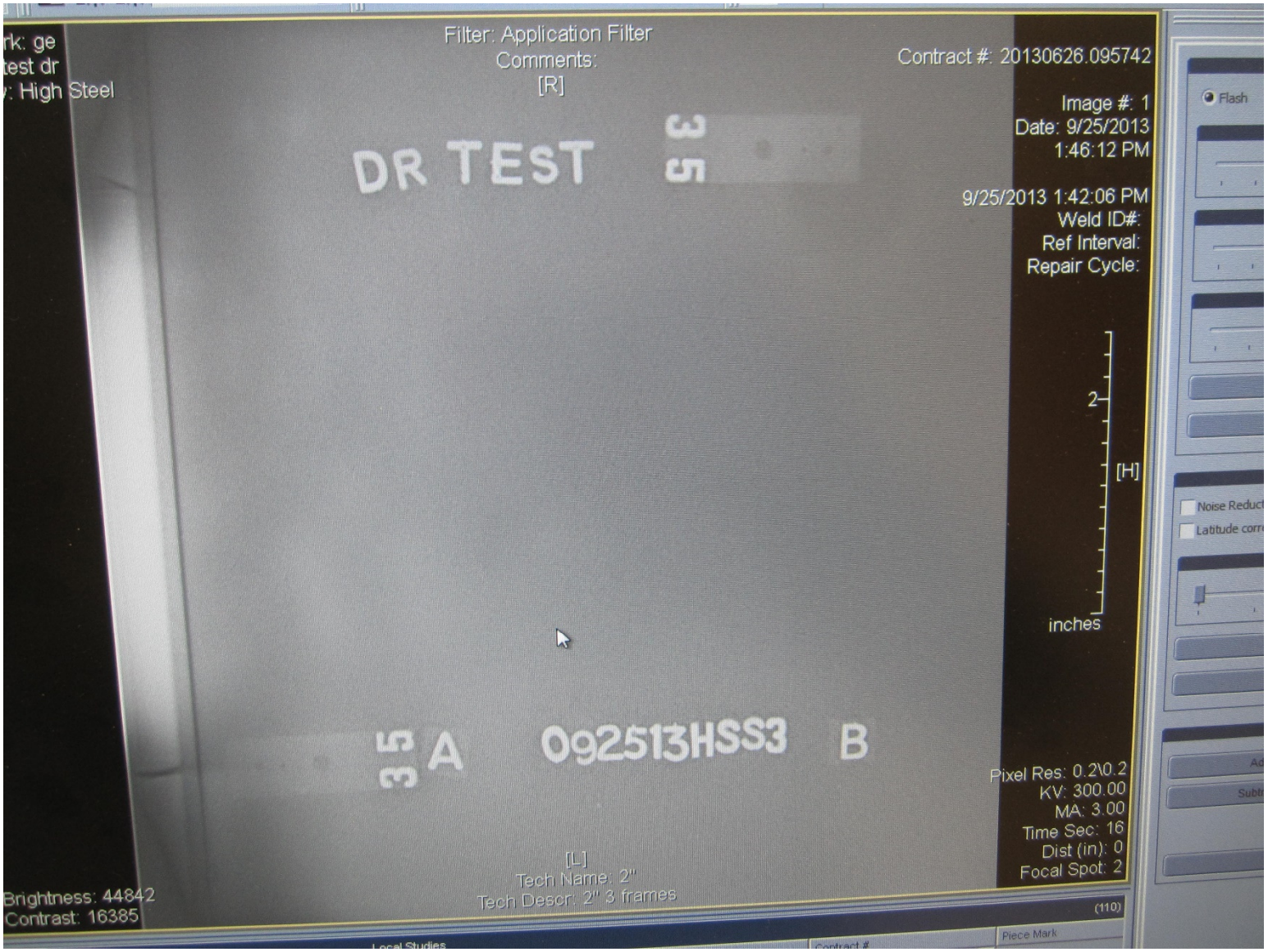
Folder	NEW/SEEN ...	Study Date	Study Status ID	Job Number	Contract #	Piece Mark
General	NEW	9/25/2013	No Status	test dr	20130626.095742	ge
General	NEW	9/25/2013	No Status	test dr cal. plate	20130626.095742	ge
CT11004...	SEEN	8/30/2013	Accept	CT1100404A-1	92-531E	G8D TW2
CT11004...	SEEN	8/30/2013	Accept	CT1100404A-1	92-531E	G8D TW1
CT11004...	SEEN	8/29/2013	Accept	CT1100404A-1	20130623.061529	G7D TF1
CT11004...	SEEN	8/29/2013	Accept	CT1100404A-1	20130623.061529	G8D TF1
CT11004...	SEEN	8/27/2013	Accept	CT1100404A-1	92-531E	G7D TW2
General	SEEN	8/27/2013	No Status	PA1110170A-5	S30980	G12D CF2
CT11004...	SEEN	8/27/2013	Accept	CT1100404A-1	92-531E	G7D TW1
General	SEEN	8/26/2013	No Status	PA1110170A-5/8/25/13	S30980	G12D TF2
General	SEEN	8/26/2013	No Status	airshot	20130826.103049	clear
General	SEEN	8/24/2013	No Status	PA1110170A-5	S30980	G12D TF2
General	SEEN	8/22/2013	No Status	PA1110170A-5	S30980	3.5 test
CT11004...	SEEN	8/19/2013	Accept	CT1100404A-1	92-531E	G7G TW1
CT11004...	SEEN	8/19/2013	Accept	CT1100404A-1	92-531E	G7G TW2
General	SEEN	8/15/2013	Reject	UT Test Plt	test	test shot
General	SEEN	8/5/2013	Accept	test pl	pa170-5	test shot
General	SEEN	7/27/2013	Accept	NY1130048A-1	D214025	G1A TF1
General	SEEN	7/27/2013	Accept	NY1130048A-1	D214025	G2A TF2
General	SEEN	7/27/2013	Accept	NY1130048A-1	D214025	G6A TF2
General	SEEN	7/27/2013	Accept	NY1130048A-1	D214025	G3A TF1
General	SEEN	7/27/2013	Accept	NY1130048A-1	D214025	G1A TF2
General	SEEN	7/27/2013	Accept	NY1130048A-1	D214025	G2A TF1
General	SEEN	7/26/2013	Accept	NY1130048A-1	0214025 BIN 5515	G3A TF2
General	SEEN	7/26/2013	Accept	NY1130048A-1	0214025 BIN 5515	G7A TF2
General	SEEN	7/26/2013	Accept	NY1130048A-1	0214025 BIN 5515	G4A TF2
General	SEEN	7/26/2013	Accept	NY1130048A-1	0214025 BIN 5515	G5A TF2
CT11004...	SEEN	7/22/2013	Accept	CT1100401A-2	92-627E	G16K TF1 R1
CT11004...	SEEN	7/22/2013	Accept	CT1100401A-2	92-627E	G15K TF1 R1
CT11004...	SEEN	7/19/2013	Accept	CT1100401A-2	92-627E	G14K TF1

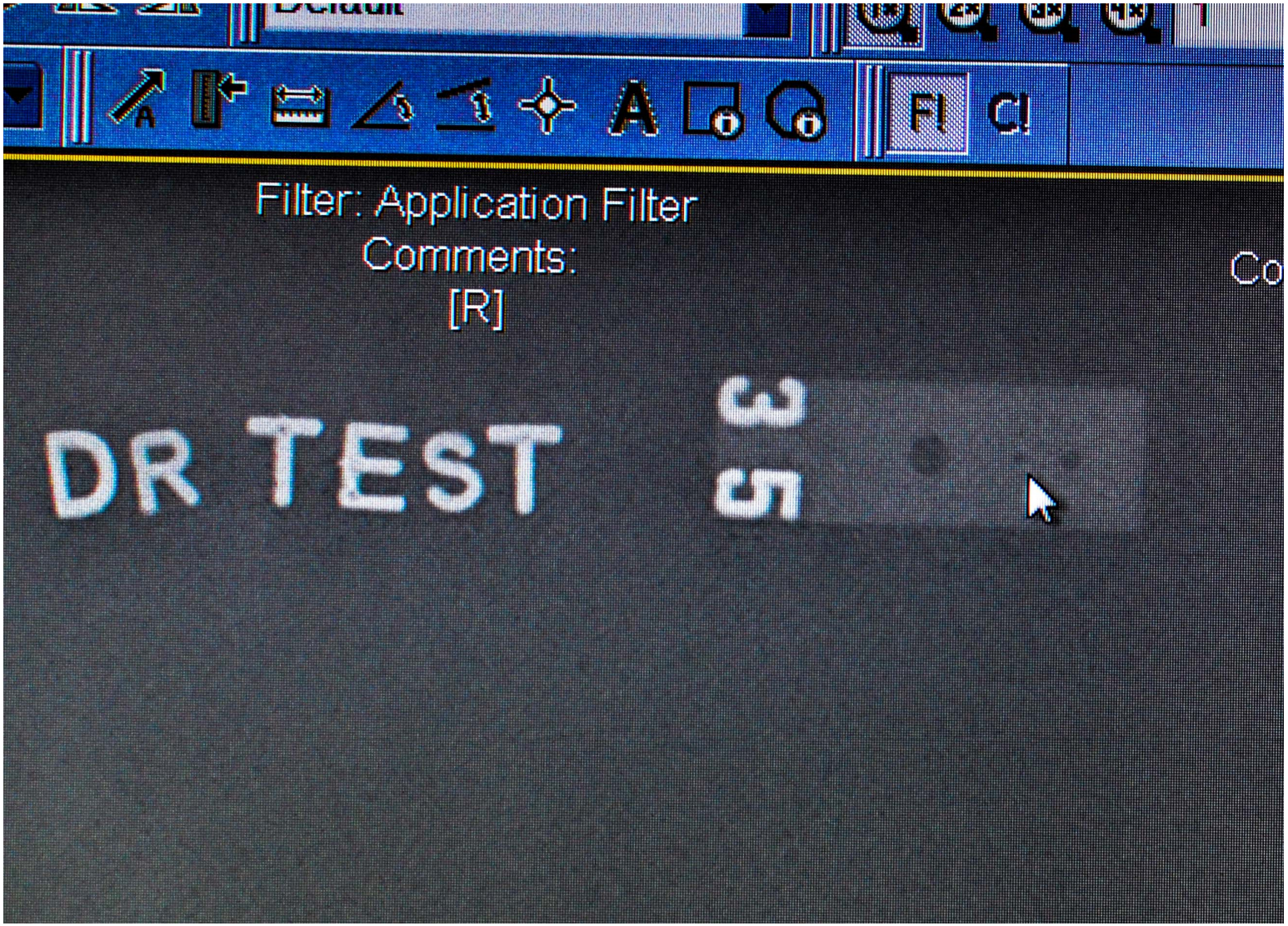

062613HSS3
Brightness: 35418
Contrast: 15012
[L]
Tech Name: 2TO3
Tech Descr:
Pixel Res: 0.2\0.2
KV: 300.00
MA: 3.00
Time Sec: 26
Dist (in): 26
Focal Spot: 2
Local Studies
(108)
Folder
NEW/SEEN ...
Study Date
Study Status ID
Job Number
Contract #
Piece Mark
Clear
CT11004... SEEN 7/10/2013 Accept CT1100404A-1 92-531E G12G TW1
CT11004... SEEN 7/10/2013 Accept CT1100401A-2 92-627E G11J TW1
CT11004... SEEN 7/9/2013 Accept CT1100404A-1 92-531E G11G TW1
General SEEN 7/8/2013 Accept NY1100107A-3 20130626.142923 G1B TW1
General SEEN 6/26/2013 No Status test 6/26 20130626.095742 ge
General SEEN 6/26/2013 No Status NY1100107A-3 20130626.142923 G4A CF2
General SEEN 6/26/2013 No Status VA25769-2D 3/26/2013 11:52: No 250C-W
General SEEN 6/24/2013 No Status VA25769-2D 3/26/2013 11:52: Restarting se
Rhythm Review 4....

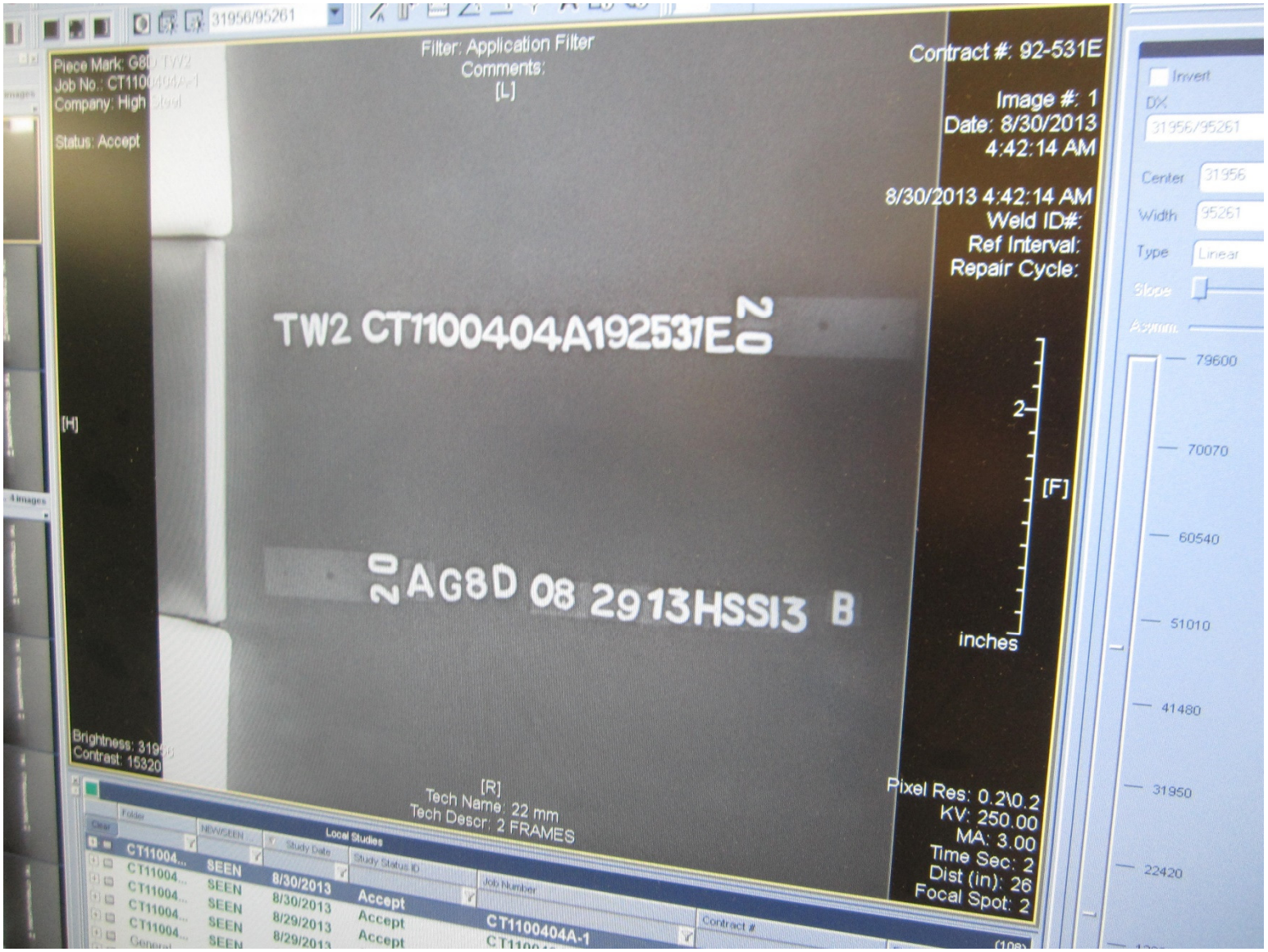
NY1120107A3D262044
CF2
12180@(447, 193)
G4A
062613HSS3
Piece Mark: G4A CF2
Company: High Steel
Image #: 1
Date: 6/26/2013
2:38:26 PM
Weld ID#:
Ref Interval:
Repair Cycle:
inches
Tech Name: 2T03
Tech Descr:
Local Studies
CT1100404A-1 92-531E G12G TW1
CT1100401A-2 92-627E G11J TW1
CT1100404A-1 92-531E G11G TW1
NY1100107A-3 20130626.142923 G1B TW1
20130626.095742 ge
NY1100107A-3 20130626.142923 G4A CF2
VA25769-2D 3/26/2013 11:52 No 250C-W

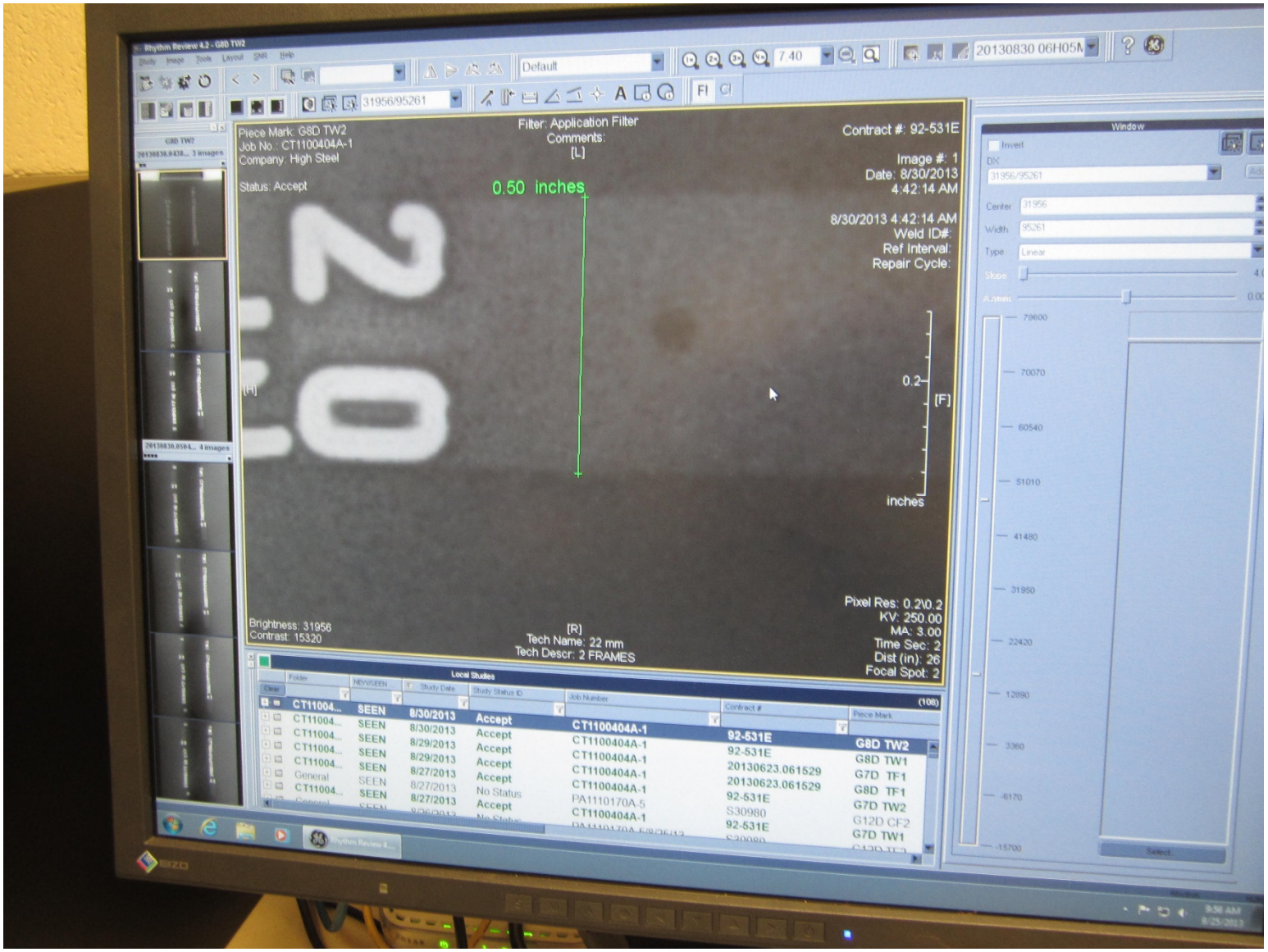

inches
Pixel Res: 0.2\0.2
KV: 300.00
MA: 3.00
Time Sec: 26
Dist (in): 26
Focal Spot: 2
(108)
Contract #
Piece Mark
92-531E
92-627E
G12G TW1
42940
35400
27860
20320
12780

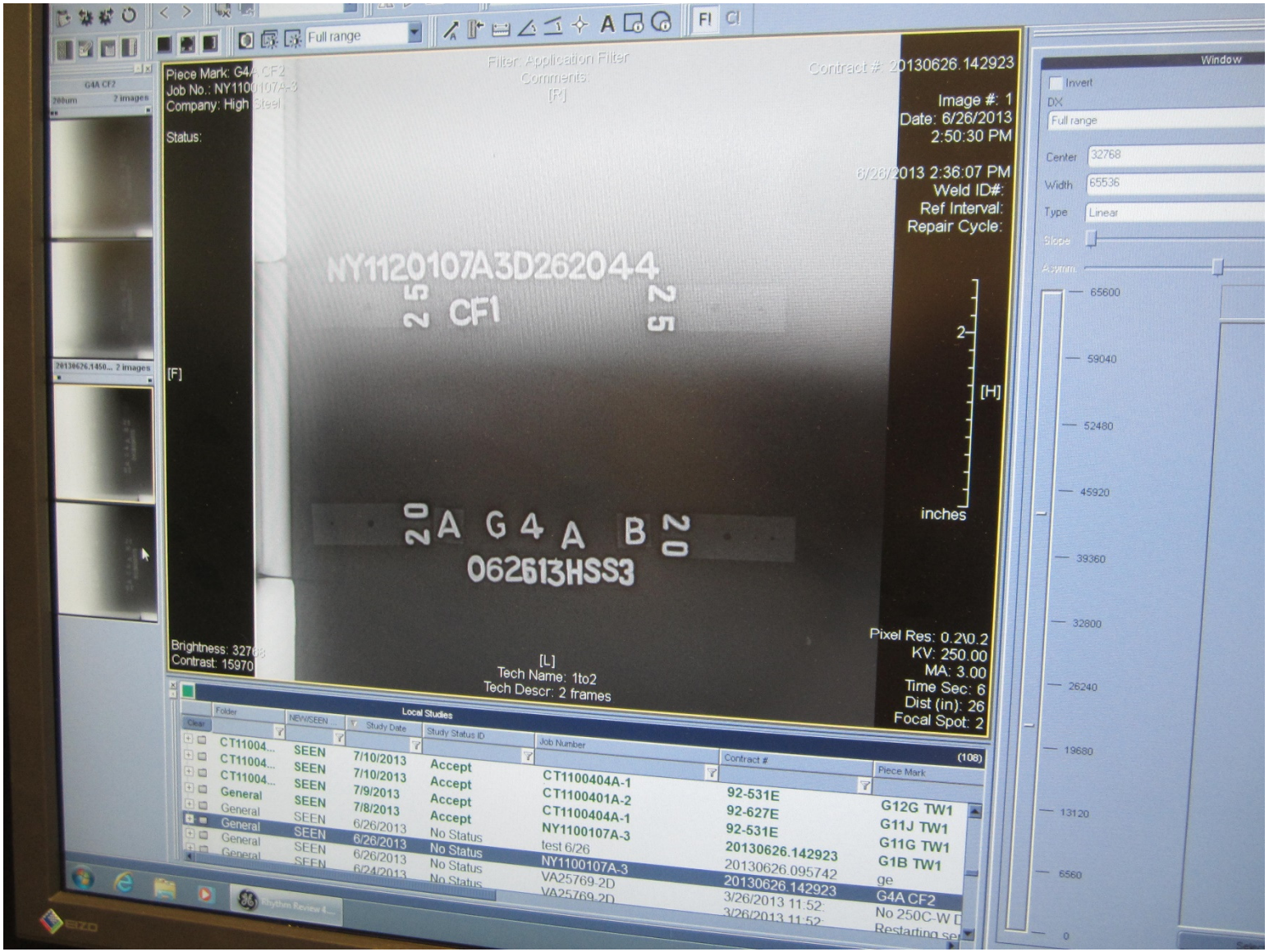

rk: ge
test dr
y: High Steel
Filter: Application Filter
Comments:
[R]
Contract #: 20130626.09574
Image #:
Date: 9/25/201
1:46:12 PM
9/25/2013 1:42:06 PM
Weld ID#:
Ref Interval:
Repair Cycle:
DR TEST
3.5
2
[H]
inches
3.5
A
092513HSS3
B
Pixel Res: 0.2\0.2
KV: 300.00
MA: 3.00
Time Sec: 16


rk: ge
test dr
: High Steel
Filter: Application Filter
Comments:
[R]
Contract #: 20130626.095742
Image #: 1
Date: 9/25/2013
1:46:12 PM
9/25/2013 1:42:06 PM
Weld ID#:
Ref Interval:
Repair Cycle:
DR TEST
35
2
[H]
inches
35 A
092513HSS3
B
Pixel Res: 0.2\0.2
KV: 300.00
MA: 3.00
Time Sec: 16
Dist (in): 0
Focal Spot: 2
[L]
Tech Name: 2"
Tech Descr: 2" 3 frames
Brightness: 44842
Contrast: 16385
(110)
Flash
Piece Mark


Filter: Application Filter
Comments:
[R]
DR TEST


Filter: Application Filter
Comments:
[L]
Contract #: 92-531E
Image #: 1
Date: 8/30/2013
4:42:14 AM
8/30/2013 4:42:14 AM
Weld ID#:
Ref Interval:
Repair Cycle:
Piece Mark: G80 TW2
Job No.: CT1100404A-1
Company: High Steel
Status: Accept
[H]
TW2 CT1100404A192531E
2
[F]
inches
AG8D 08 2913HSS13 B
Brightness: 31956
Contrast: 15320
[R]
Tech Name: 22 mm
Tech Descr: 2 FRAMES
Pixel Res: 0.2\0.2
KV: 250.00
MA: 3.00
Time Sec: 2
Dist (in): 26
Focal Spot: 2
Local Studies
CT1100404A-1
Accept
8/30/2013
8/29/2013
SEEN
Invert
DX
Center
Width
Type
Linear
Slope
79600
70070
60540
51010
41480
31950
22420

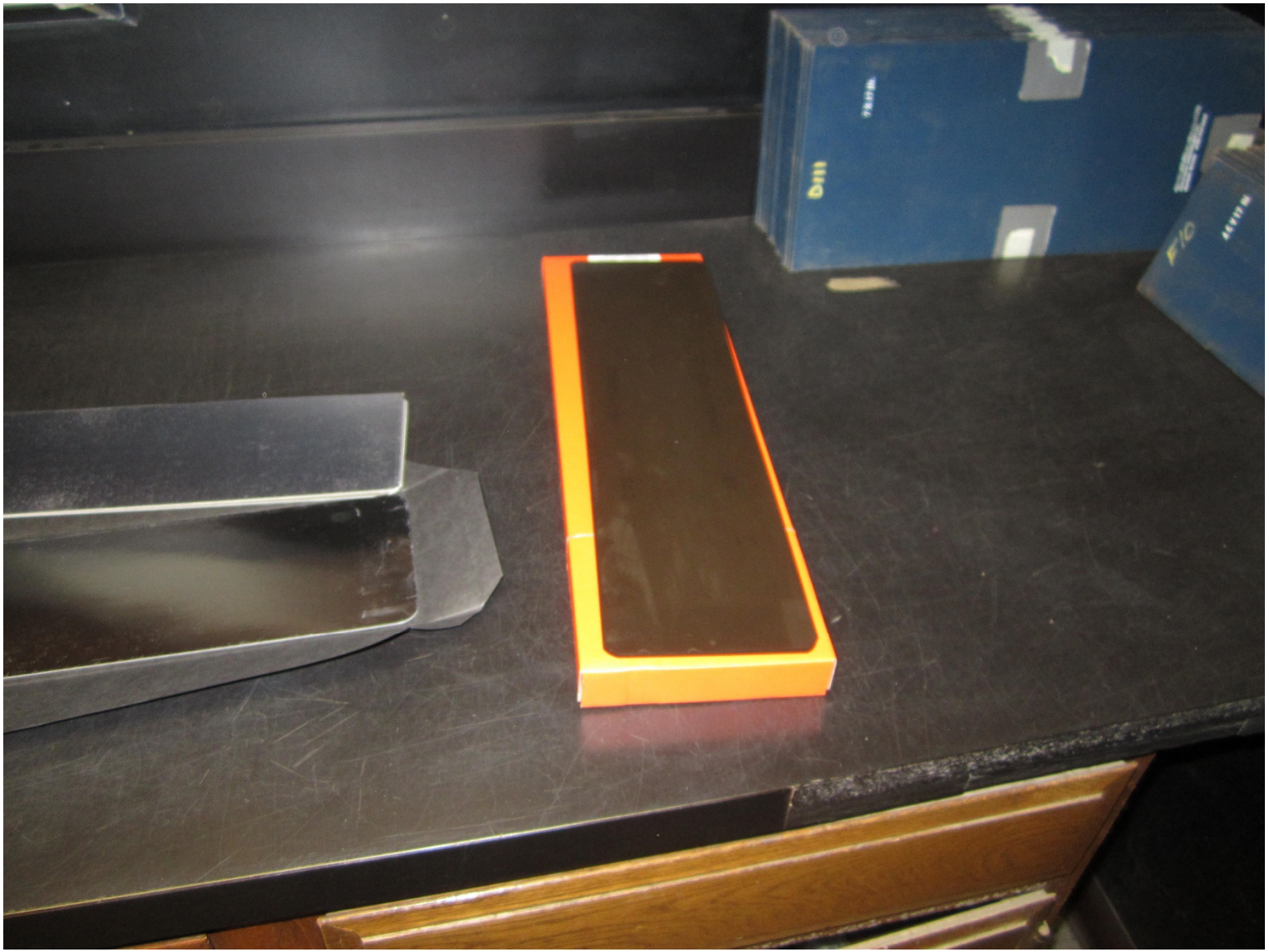

Piece Mark: G8D TW2
Job No.: CT1100404A-1
Company: High Steel
Status: Accept
Filter: Application Filter
Comments:
[L]
0.50 inches
Contract #: 92-531E
Image #: 1
Date: 8/30/2013
4:42:14 AM
8/30/2013 4:42:14 AM
Weld ID#:
Ref Interval:
Repair Cycle:
0.2
[F]
inches
[H]
Brightness: 31956
Contrast: 15320
[R]
Tech Name: 22 mm
Tech Descr: 2 FRAMES
Pixel Res: 0.2\0.2
KV: 250.00
MA: 3.00
Time Sec: 2
Dist (in): 26
Focal Spot: 2
Local Studies
Window

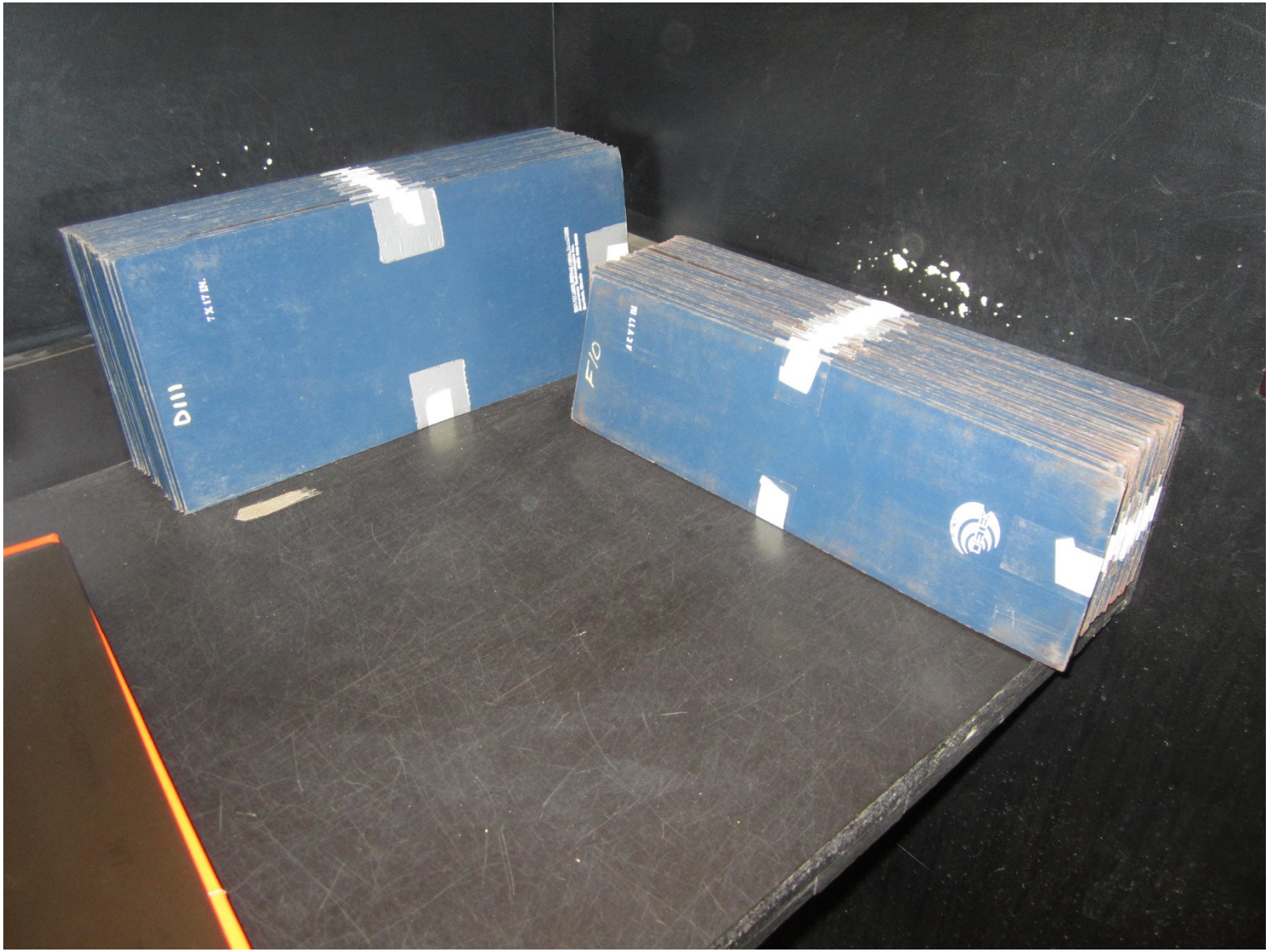

Full range
Piece Mark: G4A CF2
Job No.: NY1100107A-3
Company: High Steel
Status:
Filter: Application Filter
Comments:
[R]
Contract #: 20130626.142923
Image #: 1
Date: 6/26/2013
2:50:30 PM
6/26/2013 2:36:07 PM
Weld ID#:
Ref Interval:
Repair Cycle:
NY1120107A3D262044
25 CF1 25
[F]
20 A G4 A B 20
062613HSS3
[H]
inches
Brightness: 32768
Contrast: 15970
[L]
Tech Name: 1to2
Tech Descr: 2 frames
Pixel Res: 0.2\0.2
KV: 250.00
MA: 3.00
Time Sec: 6
Dist (in): 26
Focal Spot: 2
Window
Invert
DX
Full range
Center 32768
Width 65536
Type Linear
Slope
Asymm
65600
59040
52480
45920
39360
32800
26240
19680
13120
6560
0
Local Studies
Folder
NEW/SEEN
Study Date
Study Status ID
Job Number
Contract #
Piece Mark
(108)
CT11004... SEEN 7/10/2013 Accept CT1100404A-1 92-531E G12G TW1
CT11004... SEEN 7/10/2013 Accept CT1100401A-2 92-627E G11J TW1
CT11004... SEEN 7/9/2013 Accept CT1100404A-1 92-531E G11G TW1
General SEEN 7/8/2013 Accept NY1100107A-3 20130626.142923 G1B TW1
General SEEN 6/26/2013 No Status test 6/26 20130626.095742 ge
General SEEN 6/26/2013 No Status NY1100107A-3 20130626.142923 G4A CF2
General SEEN 6/26/2013 No Status VA25769-2D 3/26/2013 11:52 No 250C-W D
General SEEN 6/24/2013 No Status VA25769-2D 3/26/2013 11:52 Restarting se

This is what we don’t need!

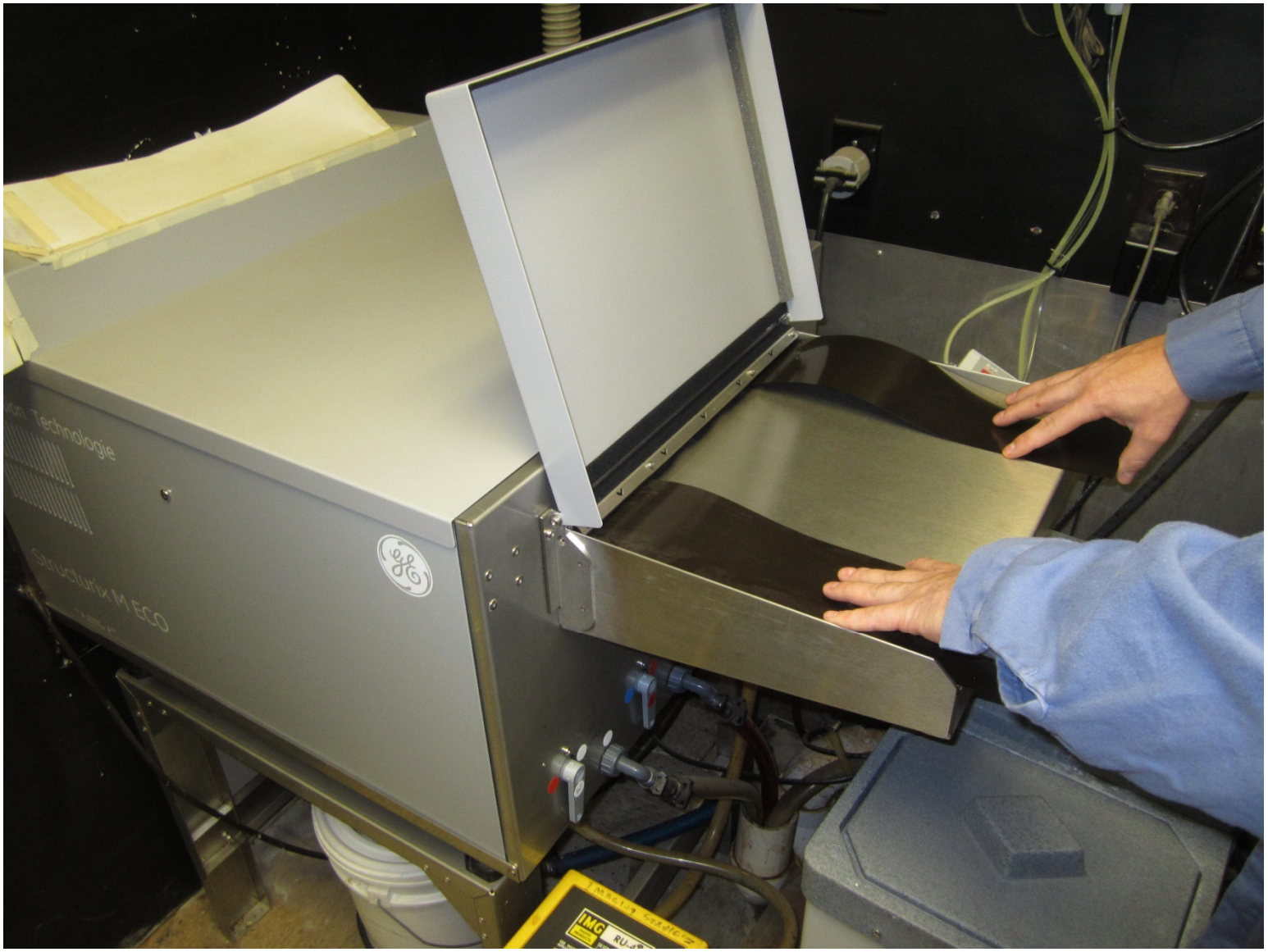
Darkroom

AGFA
Don't shut the processor off.
Leave on to allow water to
circulate. This should help with
the algae problem.
Thanks,
Dave C.


Dell
F10


7 X 17 IN.
D111
F10
IN LLA3Y

THIS SIDE UP
CORROSIVE
8
G 135 S
AGFA
G 135 S
AGFA


Technologie
Structurix M ECO
IMG

OH1100163C-6
PA 122
NY 107-3
CT 1100404A-1
NY-068A-1
PA1110170A-5
PA1110170-5

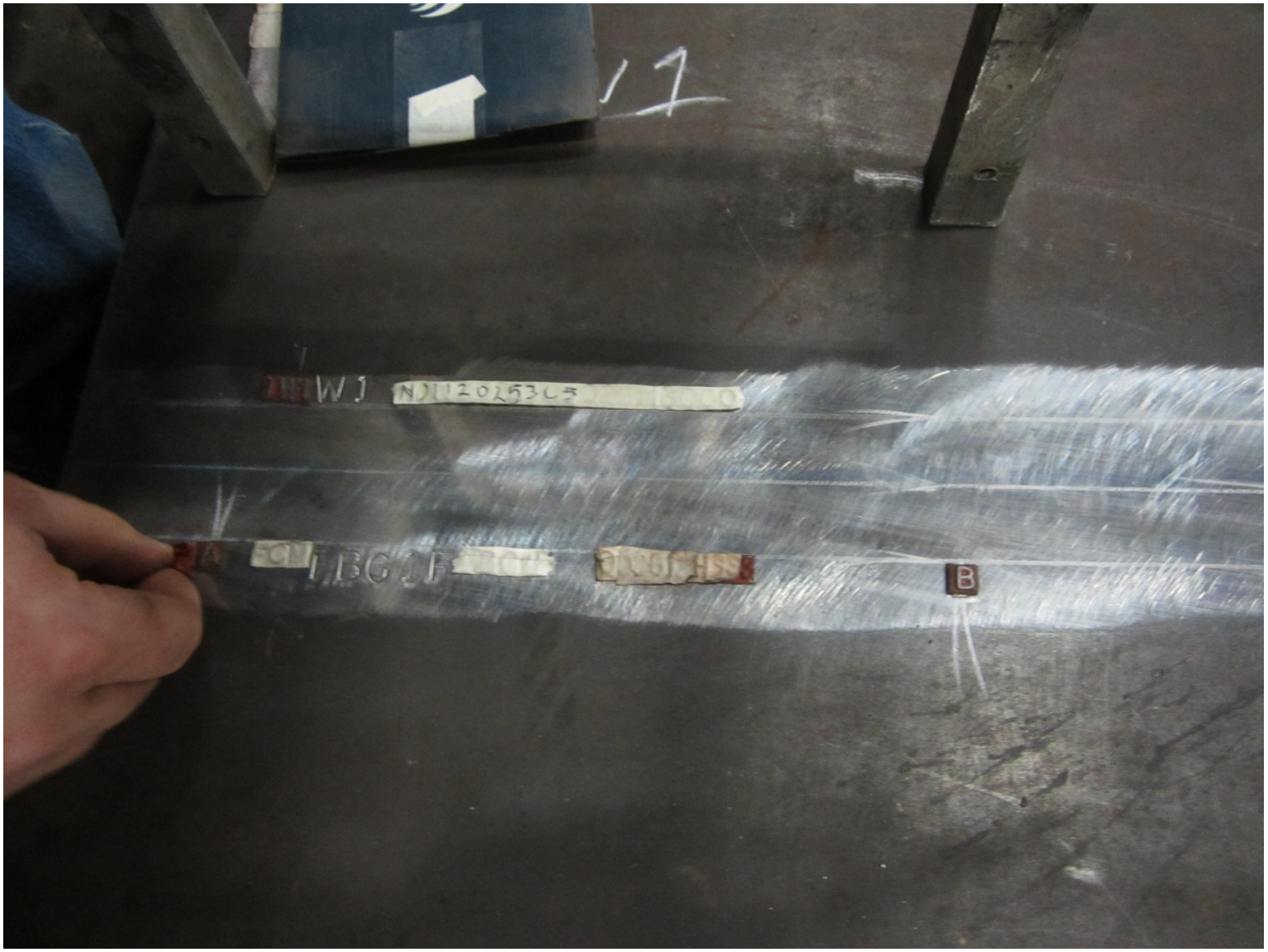
DETEK, INC.
6805 COOLRIDGE DRIVE
TEMPLE HILLS, MD 20748
800-638-0554
FAX: 301-449-7011
www.detek.com
START
CAL
SELECT
RT 120
TECHKON
PROPERTY OF
RATE
ORE
EACH USE
OFF
ON
B

This stays the same.

PLEASE
HANDLE WITH CARE
FRAG
Canadian Admiral
mr/hr CHECK
CHECK
HIGH
OFF
LOW
EMERGENCY MEASURES
ORGANIZATION
LOW RANGE
SURVEY METER
MODEL CDV 700 SCA
SERIAL NO.
HIGH
CAL.

X-RAY

Gox classic


WJ
B

CW
FBG1

X-RAY

DANGER
HIGH
RADIATION
AREA

CAUTION
DO NOT ENTER
KEEP OUT
RADIATION AREA

Digital Radiography Advantages

1. Exposure time reduced to as much as 5%
   a. Allows the use of X-ray vs Isotope
   b. Saves X-ray tube for overheating and wear
   c. X-ray has greater sensitivity than isotope
   d. Safer
2. No Film, developing or chemicals
3. Unlimited storage
4. Immediate review
5. Transfer Electronically to owner
6. Storage remains at top quality

- Research Efforts – Phased Array Inspection

NCHRP

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

2017 Annual Report

The National Academies of
SCIENCES · ENGINEERING · MEDICINE

TRB
TRANSPORTATION RESEARCH BOARD

Virginia Department of Transportation

UPDATE ON NCHRP 14-35

ACCEPTANCE CRITERIA OF CJP STEEL BRIDGE WELDS EVALUATED USING ENHANCED ULTRASONIC METHODS

Dr. Robert Connor
Dr. Glenn Washer
Curtis Schroeder
Bridget Crowley
Phil Fish

2018 Mid-Atlantic QA Workshop

Dover, DE

February 13-15, 2018

Fish & Associates Inc.
Partners in Structural Solutions

PURDUE UNIVERSITY

DISCLAIMER

The opinions and conclusions expressed or implied in this presentation are those of the research agency. They are not necessarily those of the Transportation Research Board, the National Academies, or the program sponsors.

Objectives:

- Develop guidelines to evaluate CJP welds based on updated acceptance criteria
  - Shop and field fabrication
  - In-service evaluation
  - Include procedures for using enhanced UT methods
- Develop proposed modifications to AWS D1.5

Schedule:

- *Phase I – Planning*
  - Complete
- *Phase II – Analytical Program*
  - Complete
- *Phase III – Testing Program*
  - Scheduled completion Spring 2018
- *Phase IV – Guidelines Development and Proposed Modifications to AWS D1.5*
  - Scheduled completion Summer 2018
- *Phase V – Final Products*
  - Scheduled completion Fall 2018

Literature Review Main Findings

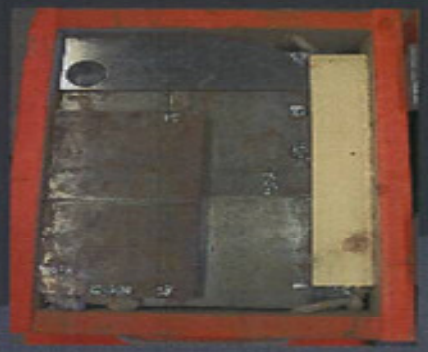
- Current AWS D1.5 conventional UT acceptance criteria
  - Shown to be highly variable in reported amplitude
- Very little documented use of enhanced UT in the bridge industry
  - Need to collect round robin data to evaluate current practice and develop improvements
- No documentation on development and basis of AWS D1.5 Annex K PAUT procedure and acceptance criteria
  - How does it compare to conventional UT results?
  - How does it compare to fracture-mechanics based acceptance criteria?

Analytical Program Main Findings

- Determined recommended critical defect sizes based on Fitness-for-Service (FFS)
  - Calculated critical defect size for fatigue and fracture limit states
  - Performed parametric study assuming:
    - Equal thickness & thickness transition butt welds
    - Plate thickness varied from 0.5" to 4"
    - Through-thickness defect position:
      - Mid-depth, quarter point, & near surface
    - Defect aspect ratio (a/c ratio)
    - Varied material grade, stress range, & fracture toughness

Experimental Program Overview

- Performed initial round robin testing program
  - Circulated numerous plates with weld flaws
  - Collected scan results:
    - 4 PAUT technicians
    - 5 conventional UT technicians
    - 2 TOFD technicians



Experimental Program Overview

- Compared initial round robin results
  - Error of flaw length and flaw height sizing
  - Hit rate (flaw detection), flaw rejection rate, and false call rate
  - Amplitude vs flaw size
  - Scatter of maximum reported amplitude
  - Error of reported flaw location
  - Classification of defect type (planar/volumetric)

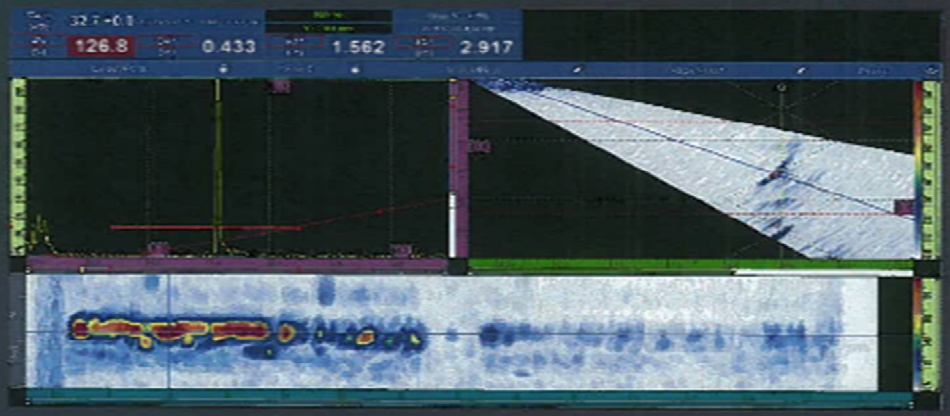
Future Work

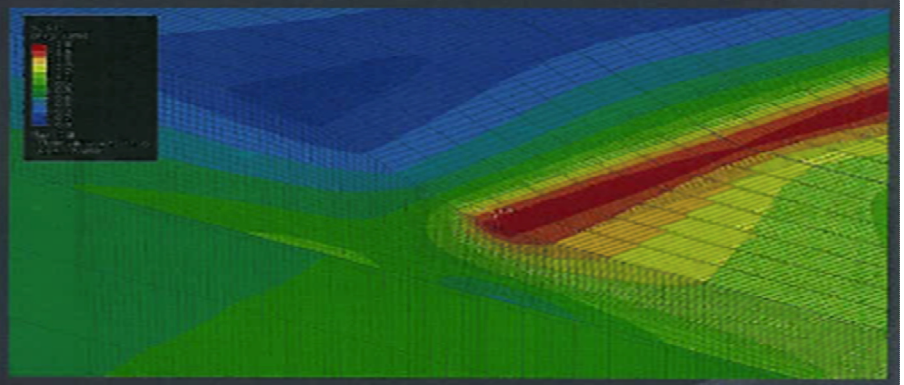
- Develop improvements to AWS D1.5 Annex K
  - Computer modeling of scan results (CIVA-UT)
  - Physical testing of weld flaw samples
  - Tie amplitude-based acceptance criteria to critical crack sizes (FFS)
- Provide table of critical flaw sizes for future acceptance criteria based on flaw sizing
  - Provide opportunity for use of future advanced technologies

Questions/Comments

Dr. Robert Connor (rconnor@purdue.edu)

Curtis Schroeder (cschroe@purdue.edu)





PURDUE UNIVERSITY

Fish & Associates, Inc.
Partners in Structural Solutions

FHWA Research

Phased Array Ultrasonic Testing

Objectives: This study focuses on evaluating the latest ultrasonic weld inspection technology and generating the qualification data required to enable ultrasonic testing techniques to replace the radiography requirements in the AWS D1.5 steel bridge fabrication requirements. To achieve this goal, the following three specific tasks will be accomplished:

1) Evaluate the feasibility of implementing Full Matrix Capture (FMC) and Total Focusing Method (TFM) technologies to improve ultrasonic flaw sizing and characterization.

2) Utilize state-of-the-art ultrasonic sound beam modeling to evaluate AWS D1.5 flaw detection performance. The generation of virtual qualification data using simulation software will produce the diverse database of flaw detection performance data required to justify the use of ultrasonic inspection for all AWS D1.5 applications.

3) Evaluate advanced ultrasonic techniques for AWS D1.5 applications. This task will include the evaluation of new advanced technologies for potential incorporation in AWS D1.5 including two dimensional arrays and time of flight diffraction techniques.

Status: Nearing completion of Task 1 on FMC/TFM technology evaluation with the following primary conclusions: 1) initial evaluations indicate that the application of FMC/TFM technology is both technically feasible and cost effective for the reliable detection and sizing of typical AWS D1.5 bridge fabrication welding flaws and 2) published literature suggests that the following benefits can be expected using FMC/TFM technology:

- Improved flaw characterization by producing an image more representative of the actual flaw shape
- Improved flaw sizing, particularly in the through-wall dimension
- More accurate flaw characterization and sizing without the need for more complex techniques like time of flight diffraction
- Supports fracture mechanics based ultrasonic acceptance criteria (current NCHRP program)

Contact: Hoda Azari, Hoda.Azari@dot.gov, 202-493-3064

Florida Department of Transportation

Evaluation of Phased Array Ultrasonic Testing for use in Bridge Fabrication

Jordan Wind – BVNA NDT Manager, ASNT UT III - #155638, AWS CWI #17010091

Jeff Comparato, Florida P.E. #83008 – Welding Engineer, AWS CWI #93110591

Miguel Diaz, Florida P.E. #78014 – Project Manager

Walter Borkowski - BVNA Sr. QA Inspector, UT/PAUT II, AWS CWI #93100171

Doug Yates – BVNA Sr. QA Inspector, RT-I, UT/PAUT II, AWS SCWI #09060048

January 12, 2018

Virginia Department of Transportation

Florida DOT

- Objective to determine how PAUT compares to conventional Radiographic (RT) and Ultrasonic (UT) testing and consider whether PAUT is a viable solution to substitute or possibly replace conventional RT and UT in Bridge Fabrication Inspection

Florida DOT

- Performed Phased Array Ultrasonic Testing (PAUT) of steel bridge welds – normal Complete Joint Penetration (CJP) welds for webs and flanges – not T and corner joints

Florida DOT

- Evaluated cost comparisons of RT and PAUT
  - Equipment costs were shown for Isotope Radiography (IR-192) and film. Therefore annual costs were considerably higher if done in house. If performed by outside vendors much closer to being equal.
  - In addition other RT costs related to Radiation Safety were noted.

Florida DOT

- Utilized traditional PAUT equipment (Olympus Omni Scan) for the evaluations - 5mhz 32 elements & 64 elements (code allows 1-6mhz)
- Testing done in accordance with AWS D1.5 Annex K. Discussion of development of a different calibration block.
- 303 Scans of weldments at 2 FDOT fabricators – all productions welds - 4% rejection rate. RT – Rejected 8% UT 1%

Conclusion

- PAUT Satisfactory – more efficient, cost-effective portable and a safe alternative to RT.

- Recent Phased Array Equipment & Technology

TOPAZ 64

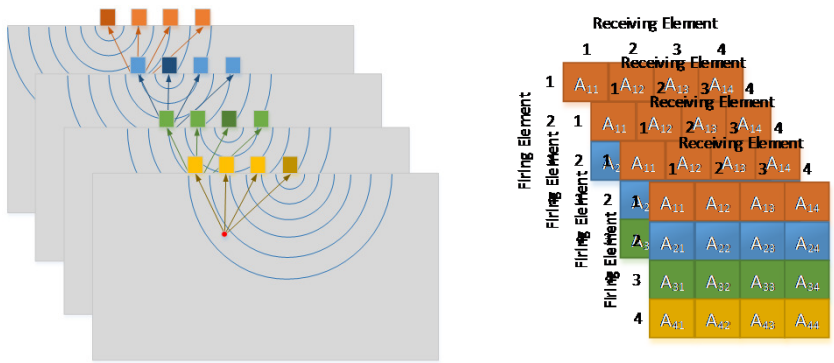
NEW

- FMC/TFM in standard and high resolution up to 1M points (1024x1024 pixels)
- New Bipolar pulsers deliver 150Vpp
- Raw A-Scan data saving
- Time Reversal option

Understanding FMC

Under standing FMC

- Full Matrix Capture (FMC) technique *captures and records all A-Scan signals from every transmitter-receiver pair*

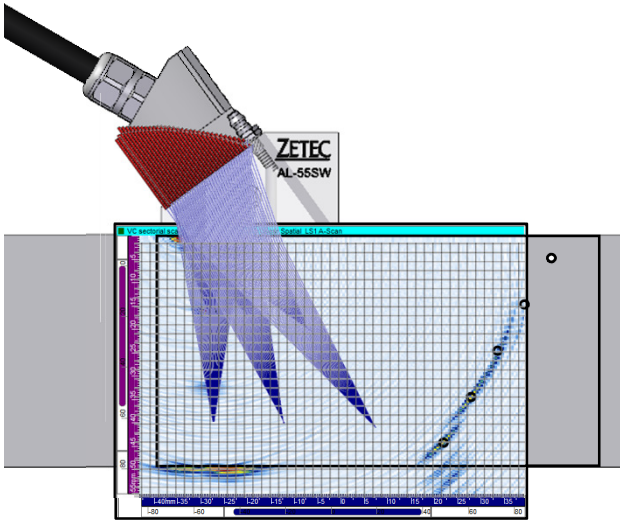


- With raw A-scan signals stored, it is possible to generate UT imaging for *any given focal law / beam* (aperture, angle, focus depth) or use for *improved algorithms* (e.g. TFM) through *post processing*

FMC + Data Reconstruction process

- Delay laws are generated, but not used during data collection
- Each element in the probe is pulsed and A-Scans for each pulser/receiver combination are digitized
- FMC data can be processed in the instrument or transferred to host computer
- FMC data can be processed as:
  - Standard focal law to reconstruct (standard phased array)
  - TFM focal law to reconstruct TFM frame
  - Using other innovative algorithms…

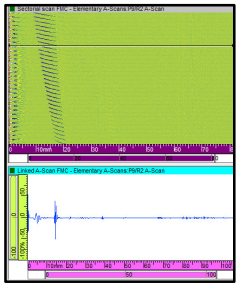
Total Focusing Method (TFM)



TFM – Frame LW

- A delay law is created for every pixel in the TFM frame
- For every pixel, A-Scan data is summed using a focal law

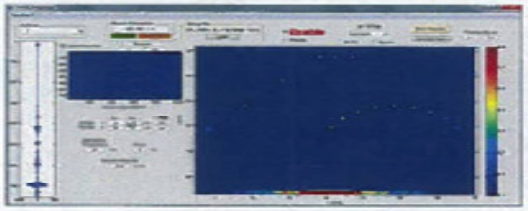
→<u>Every pixel has a perfectly focused dedicated focal</u>



FMC/TFM – Important Distinction!

- (FMC) Full– Matrix Capture = Data Acquisition
  - Performed in the hardware

- (TFM) Total Focusing Method = Post–Processing Imaging of the FMC Data
  - Performed in the software
  - A family of techniques



Full–Matrix Capture (FMC)

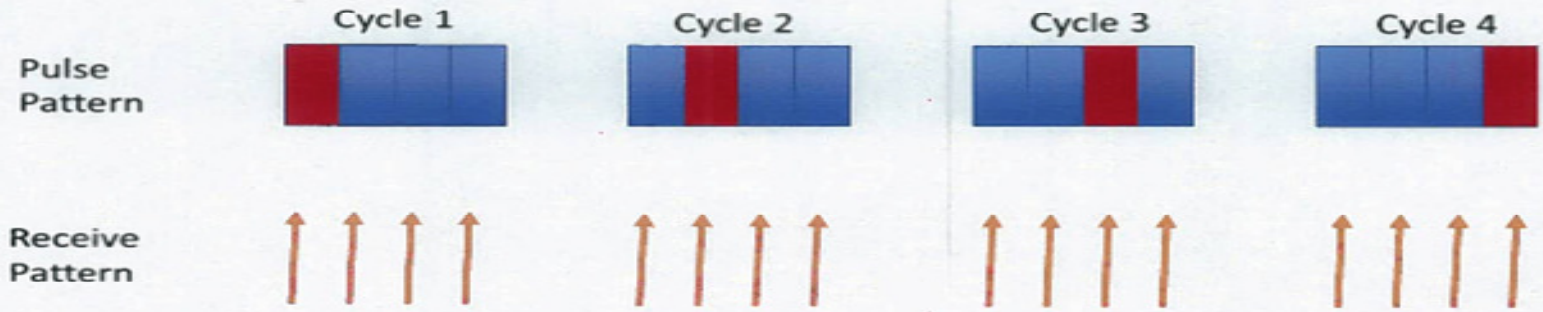
- FMC describes a pulse/receive method implemented in data acquisition hardware.
- There is no beam forming done in the hardware (no delay/focal laws)
- No specific focal spot/zone –
  - **Focused Everywhere!**
- Once the data is captured and streamed to the PC, the software must implement a post–processing or visualization algorithm.
- One popular processing technique is the Total Focus Method (TFM)

Advanced OEM Solutions

Full–Matrix Capture (FMC)

- The Pulse/Receive Sequence is…
  - Pulse on Element 1, then receive raw data on all channels in parallel without beam forming in the hardware…
  - Then pulse on 2, receive all, pulse 3, receive all… and so forth.
- One FMC for a 64 element aperture is 64 x 64 = 4,096 raw a–scans

Full–Matrix Capture (FMC)



In this example, we have 4 elements...

4 x 4 = 16 Raw A–scans

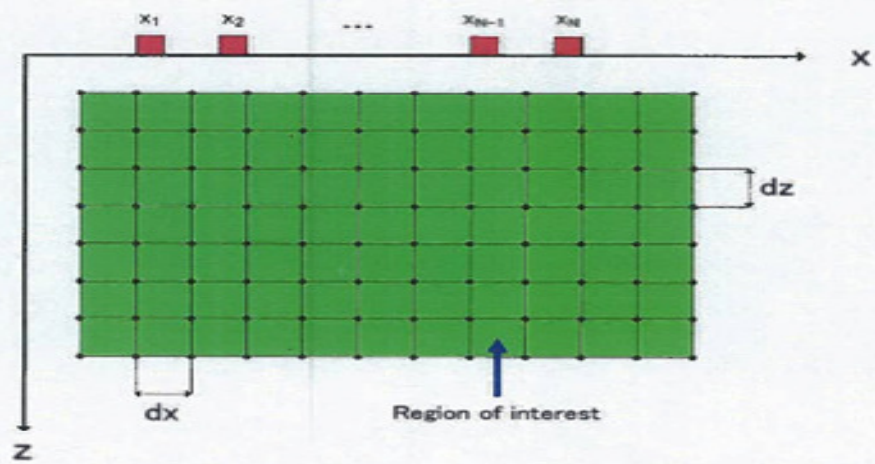
Advanced OEM Solutions

Total Focusing Method (TFM)

- TFM is an advanced image reconstruction technique, performed via software post-processing.
- By applying the TFM algorithm to FMC data, the inspection can be focused at all points within the focusable range of the probe (near field).

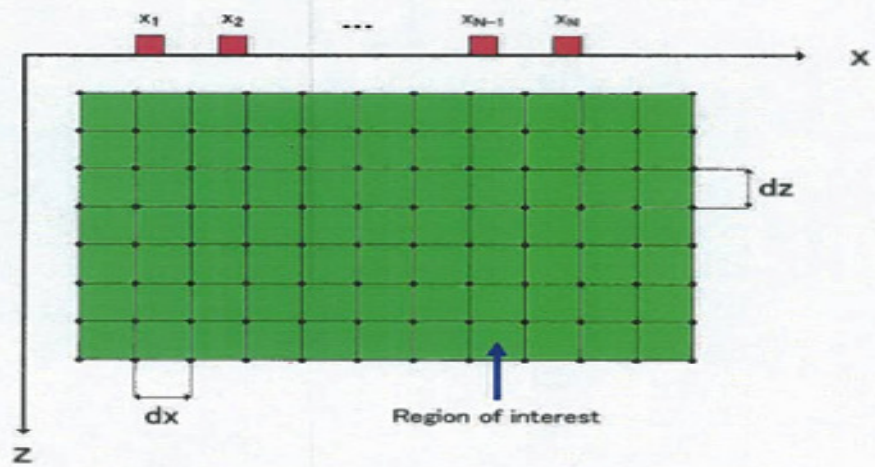
TFM – Flexible Reconstruction Grid

- User specifies inspection range, pixel resolution, and offset of reconstruction points
- TFM calculation done for each reconstruction point
- No limit to resolution (with AOS software)



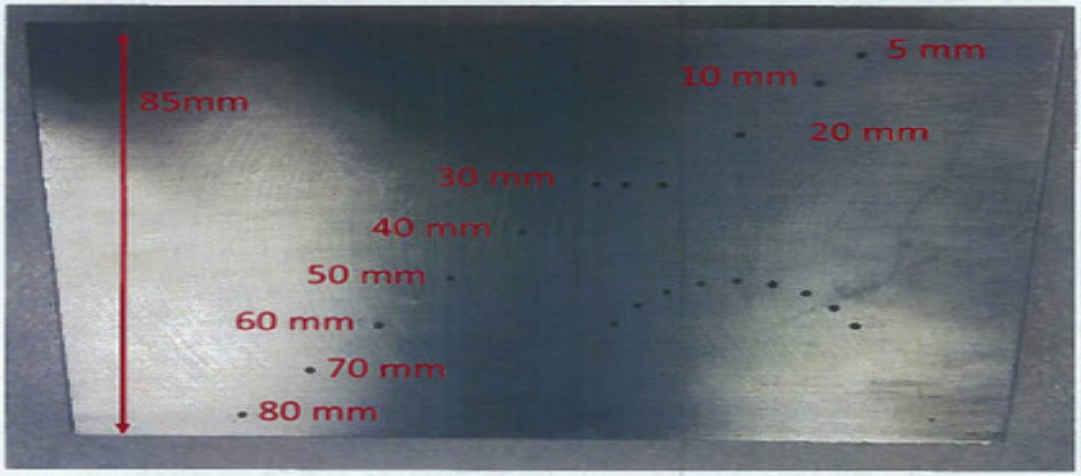
Flexible Reconstruction Grid Cont.

- The reconstruction is "Flexible", meaning when "zooming" into the inspection area to view an area of interest, the reconstruction applies the same number of specified pixels. Thus, no resolution is lost

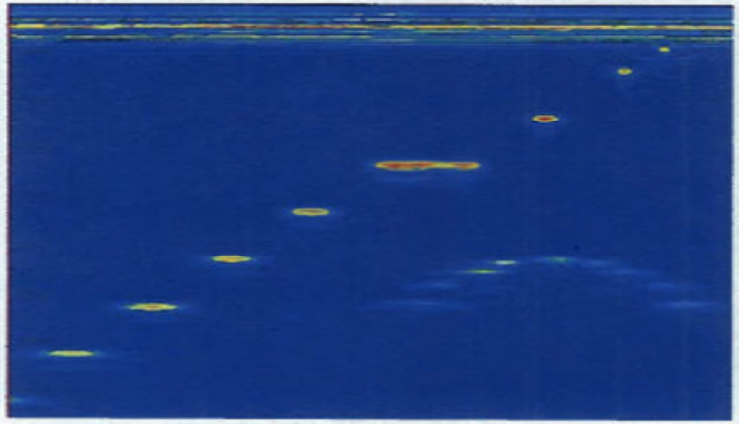


Test Piece

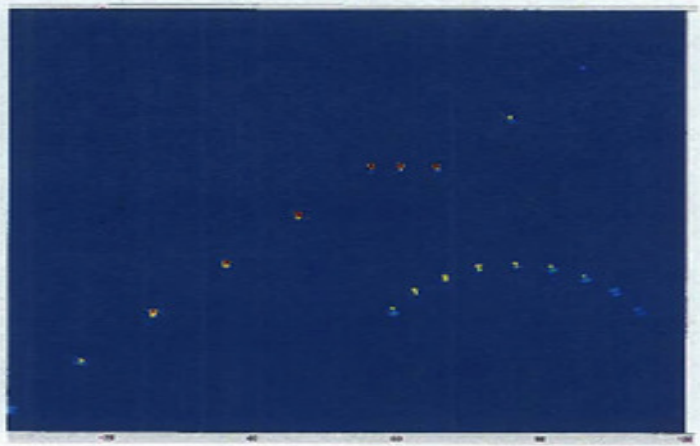
- 85 mm thick Aluminum, Ø1mm SDHs



Conventional PAUT *vs* FMC/TFM

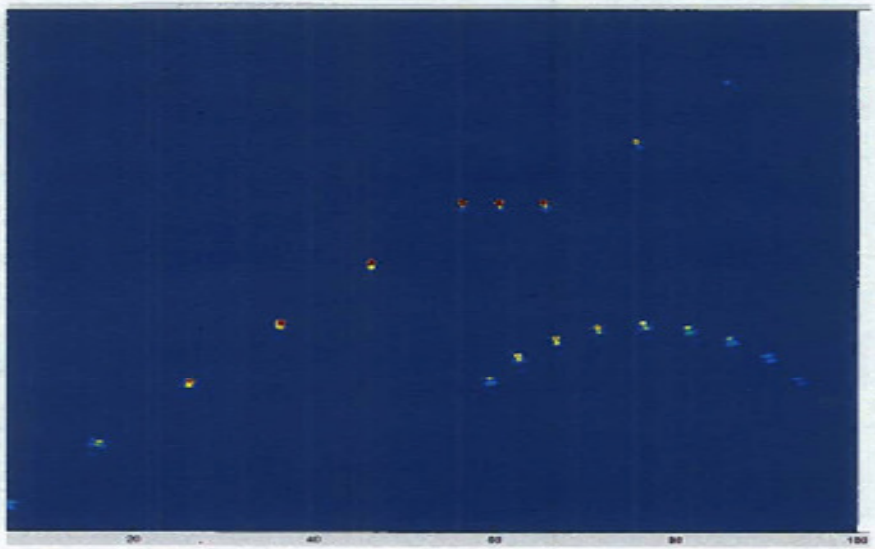


Conventional Phased Array



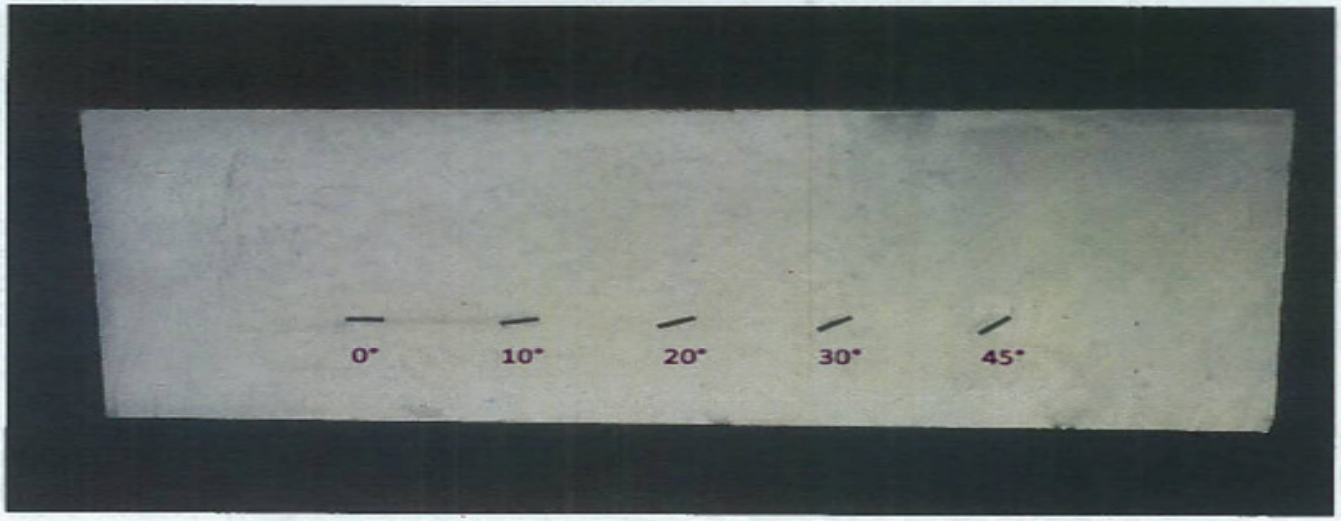
FMC/TFM

FMC/TFM

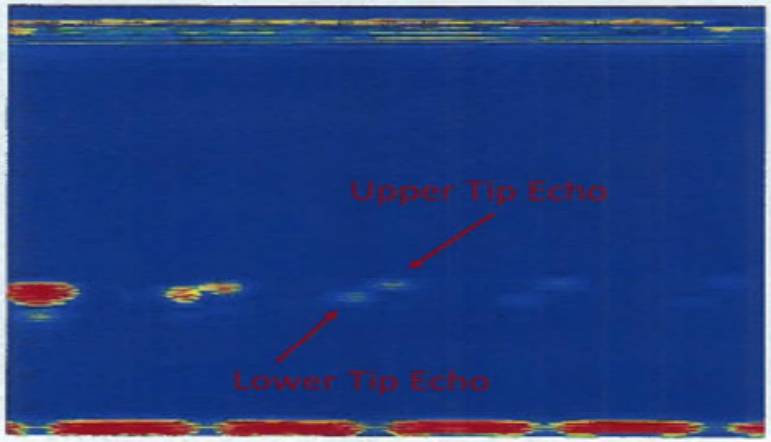


Advanced OEM Solutions

EDM Notch Test Piece



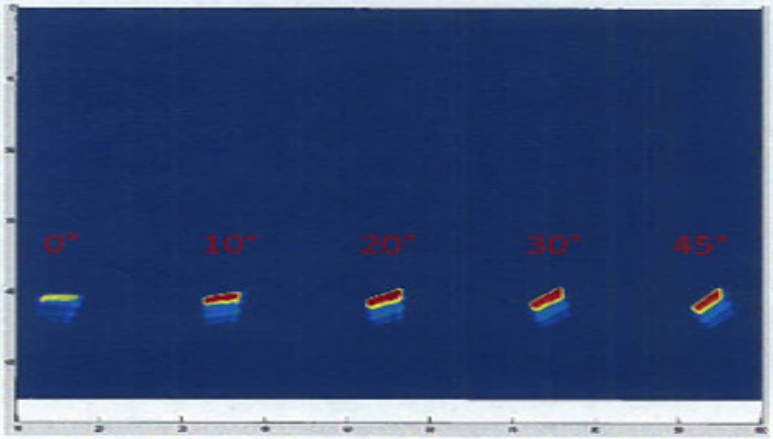
Conventional PA



- Indication from upper and lower tip.
- Center of slit is difficult to see.
- Can be easily misinterpreted as two separate defects or SDHs very close together.

TPAC The Phased Array Company

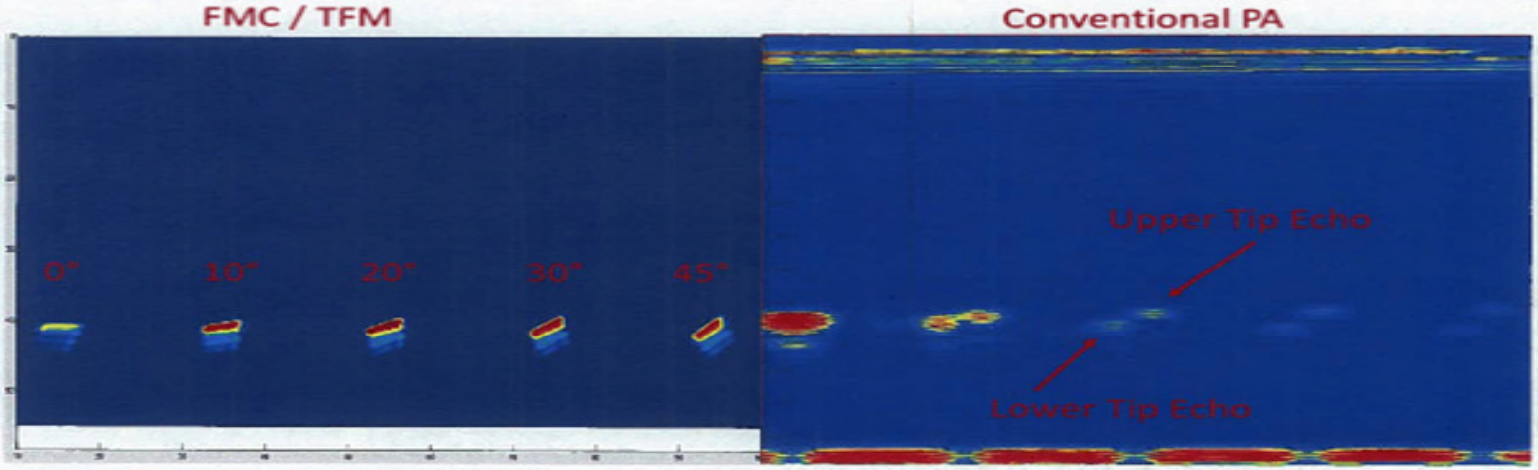
Advanced Imaging with FMC/TFM



- Can see the defect as it is
- Can see the notches even at different orientations.

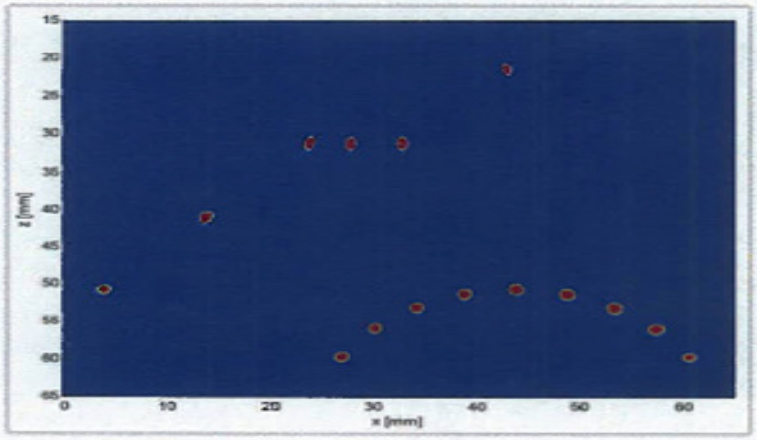
TPAC The Phased Array Company

Side By Side Comparison



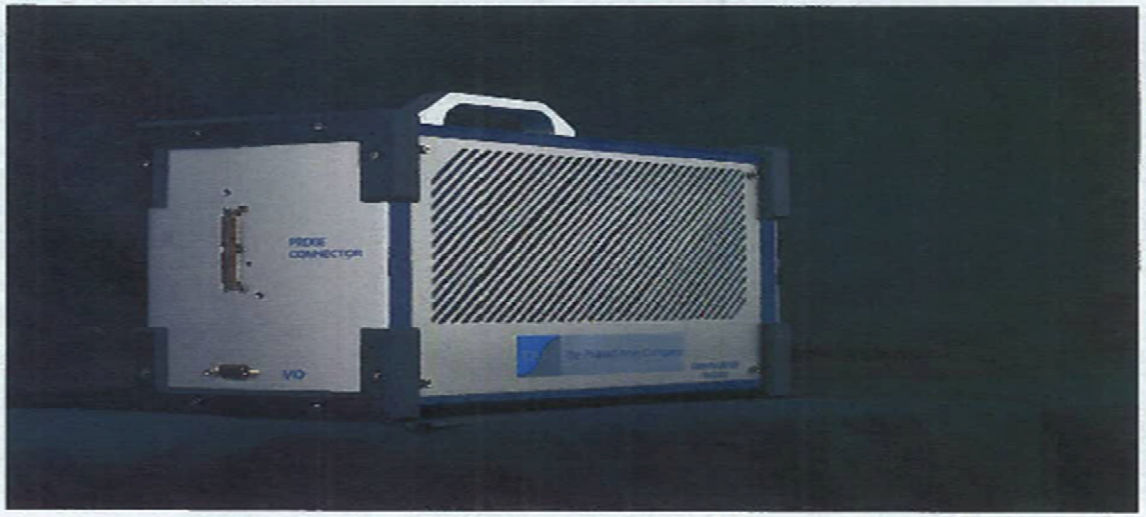
TPAC The Phased Array Company

FMC/TFM: Benefits



- Beautiful Image!
- Like a drawing of the test piece
- Provides better perspective
- Vertical Resolution Improved
- Lateral Resolution Improved
  - 3 holes: Can see the small nuance of 3 mm center to center and 4 mm center to center
- Can see that the SDHs are 1 mm in diameter.
- Understand images a lot easier
- Able to differentiate what is a real defect vs geometry echoes

Now Rugged and Field-Ready!



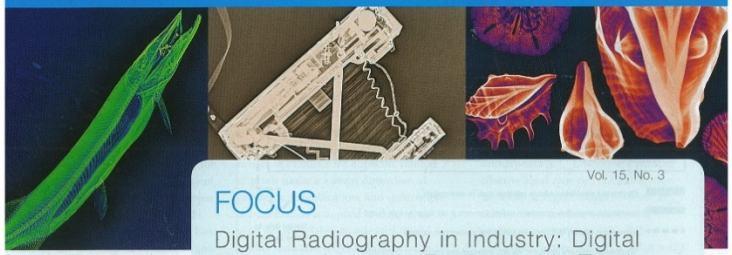
Advanced OEM Solutions

- Conclusions

Conclusions

- There have been major improvements in both UT (PAUT) and RT (Digital Radiography)
- Very specific research is being conducted on PAUT
- Digital radiography appears much superior to isotope and film radiography – (safety, cost, environmental, etc.)
- There is a code now for PAUT – AWS D1.5 (2015) Annex K
- Some states are actually utilizing PAUT and Digital RT
- Where do we want to go from here?

TheNDTTechnician



Vol. 15, No. 3

FOCUS

Digital Radiography in Industry: Digital Detector Arrays in Radiographic Testing

by Brad Kraai

Introduction

Digital detector array (DDA) systems within industrial radiography are becoming very common in high performance, critical margin of safety, and endurance test article inspections. Investment castings, thermal joints, and a wide variety of other test articles are being routinely inspected, with improved probability of detection (POD), and much faster throughput than conventional film systems—with high levels of user satisfaction. Potential users within the industrial X-ray imaging community continue to recognize these values and exploit this new technology for potential applications, but to do so, a basic understanding of DDA systems and application is a necessary foundation. Smooth implementation of this novel technology can be challenging, and consultation should be considered from an outside, unbiased, reputable organization.

There are several integrators, or vendors, that are widely recognized as providers of DDA systems development, installation, and service—each having its own merits and specialties.

This article explores DDA systems: application, capability, process controls, image attributes and evaluation, and personnel qualifications—to hopefully promote an increased interest and enlightenment for potential users.

Definitions

Per *ASTM E 2736, Standard Guide for Digital Detector Array Radiology*, a digital detector array is defined as: "an electronic device that converts ionizing or penetrating radiation into a discrete array of analog signals which are subsequently digitized and transferred to a computer for display as a digital image corresponding to the radiation energy pattern imparted upon the input region of the device. The conversion of the ionizing or penetrating radiation into an electronic signal may transpire by first converting the ionizing or penetrating radiation into visible light through the use of a scintillating material" (ASTM, 2010a). While DDAs can be used for real-time or radioscopic techniques, most applications for critical test articles employ static imaging and evaluation. Figure 1 provides a simplified diagram of a DDA.

ONTENTS

us:
tal Radiography in Industry 1
Hydrophilic Emulsifier
ncentration 8
Professional
nections 12
ctitioner Profile:
d Remmich 14

The American Society for Nondestructive Testing
www.asnt.org
IT...CREATING A SAFER WORLD!™

Virginia Department of Transportation

Questions/Comments