JOHNSON CONTROLS, INC.
812 First State Blvd
Delmarva Branch N28
Wilmington, DE 19804
(302)996-0275

Report of Eddy Current Inspection

Manufacturer: Carrier

Model: 17DA743

Serial: 01588 #6

Location: DUPONT EXPERIMENTAL STATION
200 POWER MILL ROAD
BUILDING 315
WILMINGTON, DE 19803

Inspected: December 17, 2018-December 20, 2018

Inspected By: JAYSON C. GREER, LEVEL III
TAI Services, Inc.

Reviewed By: _____
TECHNICAL MANAGER, LEVEL III

Table of Contents

Vessel Information

Manufacturer	Model	Style	Serial Number	Type
Carrier	17DA743	Open Drive	01588 #6	Centrifugal

Condenser	
TestEnd	Opposite Inlet/Outlet
Tube Count	3990
Tube Type	Skip Fin IE
Tube Material	90/10 CuNi
OD	.750
*NWT/Under Fins	.028
*NWT/Bell/Land	.055
#/Type Support	4 Mild Steel
Tube Numbering	Left to Right
Row Numbering	Top to Bottom
Tube Length +- 2	180 Inches

Sub-Cooler	
TestEnd	Opposite Inlet/Outlet
Tube Count	441
Tube Type	Skip Fin IE
Tube Material	90/10 CuNi
OD	.750
*NWT/Under Fins	.028
*NWT/Bell/Land	.055
#/Type Support	9 Mild Steel
Tube Numbering	Left to Right
Row Numbering	Top to Bottom
Tube Length +- 2	180 Inches

Analyst: JAYSON C. GREER, LEVEL III

* Nominal Wall Thickness

Vessel Bay Length Information

Condenser (Length = 180 inches)
S = Intermediate Support

Bay 5	38.00"
Bay 4	35.00"
Bay 3	34.00"
Bay 2	35.00"
Bay 1	38.00"

Sub-Cooler (Length = 180 inches)
S = Intermediate Support

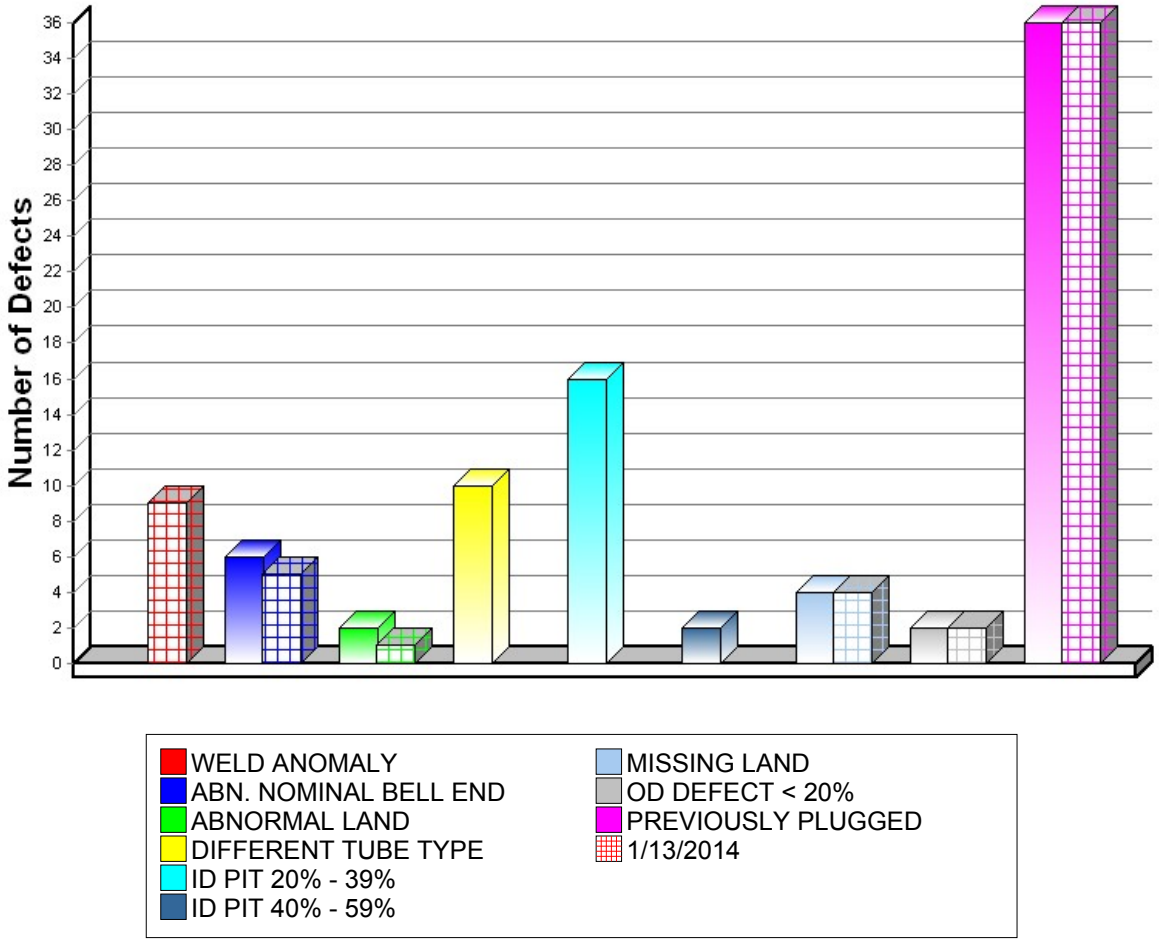
Bay 10	20.00"
Bay 9	17.50"
Bay 8	17.50"
Bay 7	17.50"
Bay 6	17.50"
Bay 5	17.50"
Bay 4	17.50"
Bay 3	17.50"
Bay 2	17.50"
Bay 1	20.00"

Defect Summary/Comparison

Comparison of Tests Performed

12/17/2018 1/13/2014

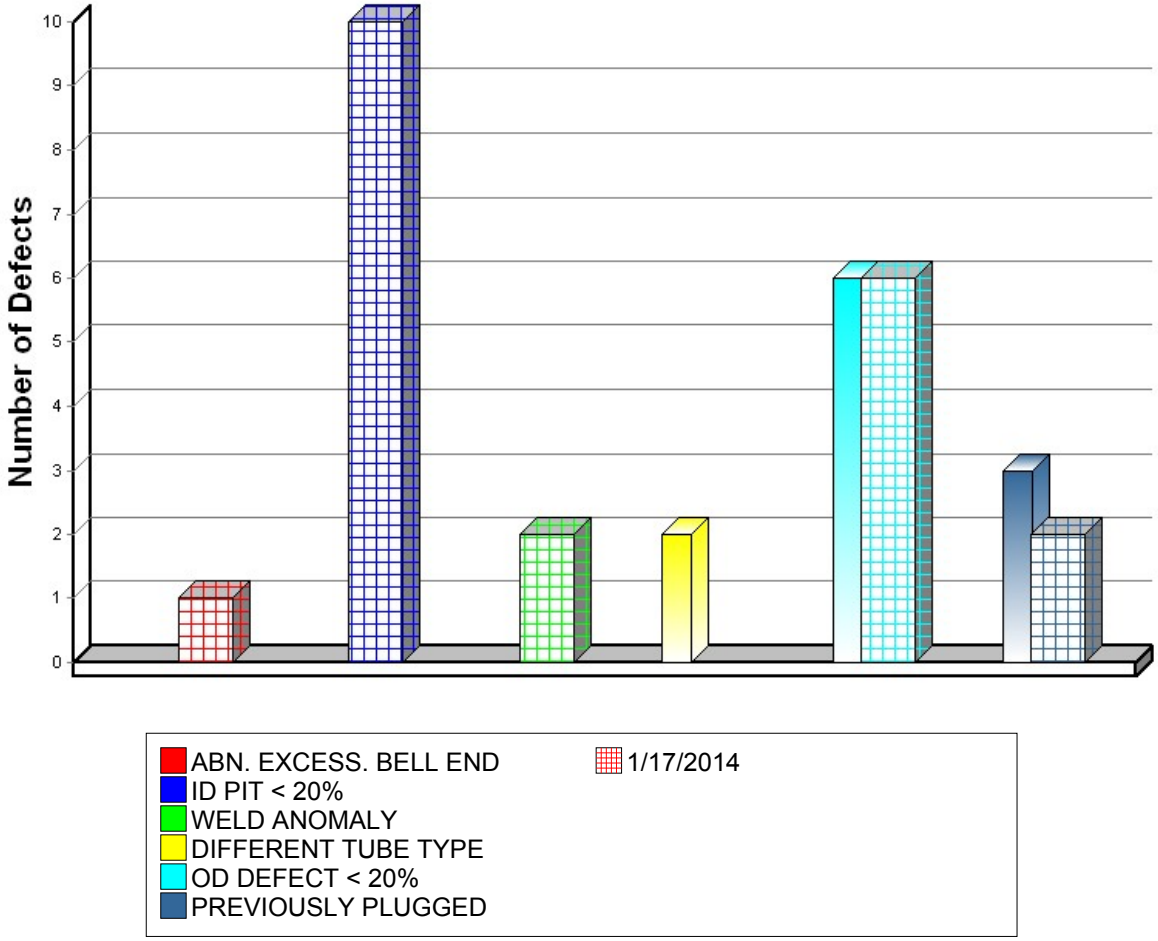
Condenser Defects



Location	Model	Serial Number
DUPONT EXPERIMENTAL STATION	17DA743	01588 #6

Note: A graph indicating the number of tubes marked for each category will be generated when tubes are marked. Indications from previous inspections will be displayed as cross hatch bars.

Sub-Cooler Defects



Location	Model	Serial Number
DUPONT EXPERIMENTAL STATION	17DA743	01588 #6

Note: A graph indicating the number of tubes marked for each category will be generated when tubes are marked. Indications from previous inspections will be displayed as cross hatch bars.

Summary of Inspection

An eddy current tube inspection was performed as part of a preventive maintenance program with the following results.

Condenser: 3990 Tubes		
Tubes Tested: 3990 Tubes		
Significant/Measurable Indications	Tubes Marked	Percent of Bundle
ABN. NOMINAL BELL END	6	.15
ABNORMAL LAND	2	.05
OD DEFECT < 20%	2	.05
DIFFERENT TUBE TYPE	10	.25
MISSING LAND	4	.10
ID PIT 20% - 39%	16	.40
ID PIT 40% - 59%*	2	.05
PREVIOUSLY PLUGGED	36	.90
Totals	**78**	**1.95**

* REQUIRES ACTION

NOTE: Although not marked, the majority of tubes gave indications of minor generalized ID Corrosion and Pitting. Only those tubes giving indications greater than 20% or more were marked in order to keep the tube chart neat and legible and to better illustrate more critical damage.

NOTE: The tubes in this vessel showed minor indications of tube wall thinning. These indications were attributed to permeability variations and not loss of mass.

Sub-Cooler: 441 Tubes		
Tubes Tested: 441 Tubes		
Significant/Measurable Indications	Tubes Marked	Percent of Bundle
OD DEFECT < 20%	6	1.36

Sub-Cooler: 441 Tubes		
Tubes Tested: 441 Tubes		
Significant/Measurable Indications	Tubes Marked	Percent of Bundle
DIFFERENT TUBE TYPE	2	.45
PREVIOUSLY PLUGGED	3	.68
Totals	**11**	**2.49**

NOTE: Although not marked, all the tubes in this bundle gave indications of minor generalized ID Corrosion and ID Pitting. No individual tubes gave indications of significant damage, and therefore none were marked.

NOTE: The tubes in this vessel showed minor indications of tube wall thinning. These indications were attributed to permeability variations and not loss of mass.

Recommendations

An eddy current inspection was performed on the tubes in this machine. This test was performed using accepted eddy current test methods for the inspection of in-service tubing. It should be noted that Eddy Current is not a leak detection method. The possibility does exist that tubes could contain defects and/or leaks which are not detectable. If leaks are suspected, we recommend a pressure test be used to identify the leaking tubes.

The following suggested repair actions are based on accepted industry standards. After removing sample tubes to confirm the inspection results, a determination of corrective action should be made by the repair agency and end user. Only these parties have knowledge of the critical applications and long-term use of the equipment. If plugging is selected over replacement, both efficiency and capacity should be considered.

CONDENSER:

Tubes indicating Abnormal Bell End Indications require no corrective action at this time. The indications are that of minor thinning at the Bell End. The exact cause and description of the anomaly is unknown.

Tubes indicating Abnormal Support Landings require no corrective action at this time. These tubes showed a distorted transition zone at the indicated support. The exact cause of the indication is unknown, but is believed to be the result of manufacturing.

The tubes marked for OD Defects require no corrective action at this time.

The tube(s) marked as "Different Tube Type" were .750/.042/.028 CuNi tubes. The test instrument was calibrated, and standard procedures were followed for this tube type and alloy. These tubes showed no measurable indications of tube damage and were marked for information purposes only.

The tubes missing support landings showed no detectable damage or loss and require no corrective action.

Tubes indicating ID Pits of 40% or more should be isolated from the system at this time. ID Pits of less than 40% require no immediate corrective action. However, this type damage is usually progressive and should be monitored.

Tubes marked as Previously Plugged, had been plugged prior to this inspection.

SUB-COOLER:

The tubes marked for OD Defects require no corrective action at this time.

The tube(s) marked as "Different Tube Type" were .750/.042/.028 CuNi tubes. The test instrument was calibrated, and standard procedures were followed for this tube type and alloy. These tubes showed no measurable indications of tube damage and were marked for information purposes only.

Tubes marked as Previously Plugged, had been plugged prior to this inspection.

RE-INSPECTION RECOMMENDATIONS:

We recommend that a follow-up inspection be performed on these vessels as follows:

Sub-Cooler: 20 December 2020

Condenser: 20 December 2020

A copy of this report should be retained in your files to be used for comparison at that time.

If you should have any questions concerning this report, or if we may be of further assistance, please feel free to call upon us.

Data Sheet

Location	Model	Serial Number	Date
DUPONT EXPERIMENTAL STATION	17DA743	01588 #6	December 17, 2018
200 POWER MILL ROAD			
WILMINGTON, DE 19803			

Row	Tube	Description	Area	Action Req.
SET UP CALIBRATE & STARTED				
CONDENSER 12/17/2018 08:06 am				
CALIBRATION CHECK 12/17/2018 02:33 pm				
CALIBRATION CHECK 12/18/2018 08:41 am				
CALIBRATION CHECK 12/18/2018 03:32 pm				
CALIBRATION CHECK 12/19/2018 08:23 am				
1	6	ID PIT 20% - 39%	B04	
1	9	PREVIOUSLY PLUGGED	TE	
3	29	PREVIOUSLY PLUGGED	TE	
3	30	ID PIT 20% - 39%	B04	
4	26	PREVIOUSLY PLUGGED	TE	
5	2	PREVIOUSLY PLUGGED	TE	
5	31	PREVIOUSLY PLUGGED	TE	
6	33	ABNORMAL LAND	S02	
6	63	ABN. NOMINAL BELL END	OTE	
7	11	DIFFERENT TUBE TYPE	TE	
7	63	ABN. NOMINAL BELL END	OTE	
8	17	ID PIT 20% - 39%	B04	
8	18	PREVIOUSLY PLUGGED	TE	
8	21	PREVIOUSLY PLUGGED	TE	
8	62	ABN. NOMINAL BELL END	OTE	

Row	Tube	Description	Area	Action Req.
9	52	PREVIOUSLY PLUGGED	TE	
10	22	ID PIT 20% - 39%	B04	
10	23	ID PIT 20% - 39%	B02	
10	24	ID PIT 20% - 39%	B04	
10	31	ID PIT 40% - 59% **Plugged by JCI - 12/21/2018**	B04	✓
10	43	PREVIOUSLY PLUGGED	TE	
11	7	PREVIOUSLY PLUGGED	TE	
11	13	ID PIT 40% - 59% **Plugged by JCI - 12/21/2018**	B05	✓
11	37	OD DEFECT < 20%	B01	
11	51	PREVIOUSLY PLUGGED	TE	
11	55	PREVIOUSLY PLUGGED	TE	
12	3	ID PIT 20% - 39%	B03	
12	7	ID PIT 20% - 39%	B05	
12	44	MISSING LAND	S02	
13	9	PREVIOUSLY PLUGGED	TE	
13	50	ID PIT 20% - 39%	B02	
13	71	PREVIOUSLY PLUGGED	TE	
14	12	PREVIOUSLY PLUGGED	TE	
14	15	PREVIOUSLY PLUGGED	TE	
14	22	DIFFERENT TUBE TYPE	TE	
15	50	ABN. NOMINAL BELL END	OTE	
16	10	ABN. NOMINAL BELL END	OTE	
16	15	ABNORMAL LAND	S03	
16	41	DIFFERENT TUBE TYPE	TE	
18	42	ABN. NOMINAL BELL END	OTE	
18	60	MISSING LAND	S04	

Row	Tube	Description	Area	Action Req.
20	71	DIFFERENT TUBE TYPE	TE	
21	30	PREVIOUSLY PLUGGED	TE	
21	35	PREVIOUSLY PLUGGED	TE	
22	2	ID PIT 20% - 39%	B03	
22	44	ID PIT 20% - 39%	B01	
23	24	PREVIOUSLY PLUGGED	TE	
24	24	MISSING LAND	S02	
26	51	ID PIT 20% - 39%	B04	
27	7	PREVIOUSLY PLUGGED	TE	
28	73	PREVIOUSLY PLUGGED	TE	
29	6	MISSING LAND	S02	
30	2	PREVIOUSLY PLUGGED	TE	
30	28	PREVIOUSLY PLUGGED	TE	
31	5	ID PIT 20% - 39%	B03	
31	28	DIFFERENT TUBE TYPE	TE	
31	63	PREVIOUSLY PLUGGED	TE	
33	8	OD DEFECT < 20%	B04	
33	14	ID PIT 20% - 39%	B05	
33	51	DIFFERENT TUBE TYPE	TE	
33	77	DIFFERENT TUBE TYPE	TE	
34	64	ID PIT 20% - 39%	B04	
35	73	DIFFERENT TUBE TYPE	TE	
36	14	PREVIOUSLY PLUGGED	TE	
36	49	PREVIOUSLY PLUGGED	TE	
36	67	DIFFERENT TUBE TYPE	TE	
37	70	PREVIOUSLY PLUGGED	TE	

Row	Tube	Description	Area	Action Req.
38	15	PREVIOUSLY PLUGGED	TE	
40	10	DIFFERENT TUBE TYPE	TE	
40	28	PREVIOUSLY PLUGGED	TE	
41	39	PREVIOUSLY PLUGGED	TE	
44	17	PREVIOUSLY PLUGGED	TE	
50	18	PREVIOUSLY PLUGGED	TE	
51	9	PREVIOUSLY PLUGGED	TE	
CALIBRATION CHECK 12/19/2018 02:38 pm				
CALIBRATION CHECK 12/20/2018 07:41 am				
53	3	PREVIOUSLY PLUGGED	TE	
53	26	PREVIOUSLY PLUGGED	TE	
53	39	ID PIT 20% - 39%	B02	
56	18	PREVIOUSLY PLUGGED	TE	
CALIBRATION CHECK & COMPLETED				
CONDENSER 12/20/2018 09:16 am				
SET UP CALIBRATE & STARTED				
SUB-COOLER 12/20/2018 09:18 am				
3	17	OD DEFECT < 20%	B08	
3	21	OD DEFECT < 20%	B08	
6	28	OD DEFECT < 20%	B09	
8	1	PREVIOUSLY PLUGGED	TE	
8	18	PREVIOUSLY PLUGGED	TE	
8	23	OD DEFECT < 20%	B10	
8	28	DIFFERENT TUBE TYPE	TE	
10	19	PREVIOUSLY PLUGGED	TE	
12	17	DIFFERENT TUBE TYPE	TE	

Row	Tube	Description	Area	Action Req.
14	16	OD DEFECT < 20%	B09	
15	5	OD DEFECT < 20%	B09	
CALIBRATION CHECK & COMPLETED				
SUB-COOLER 12/20/2018 12:34 pm				

Condenser Section

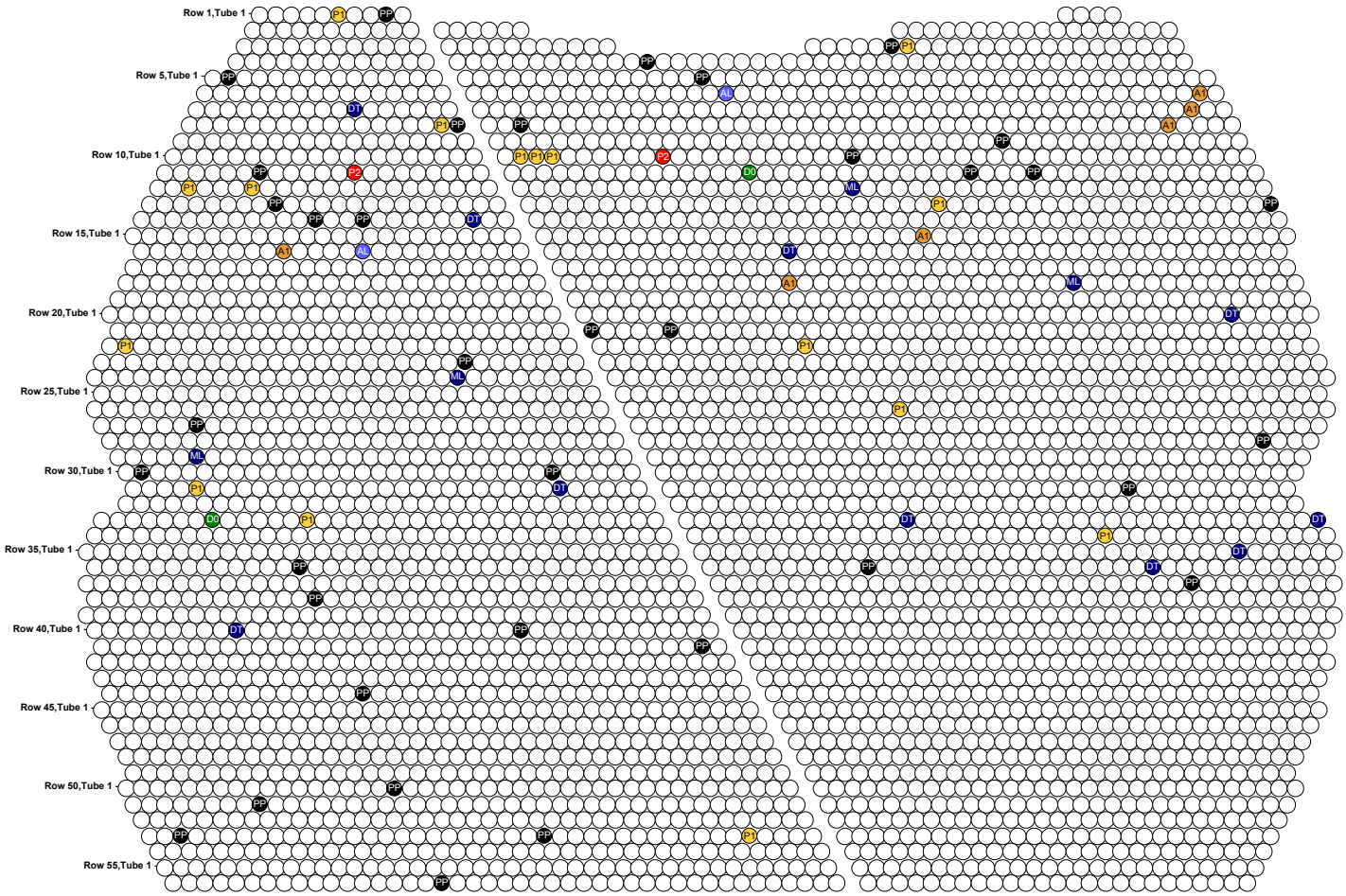
Tubes Numbered
Left to Right

Rows Numbered
Top to Bottom

Top of Vessel

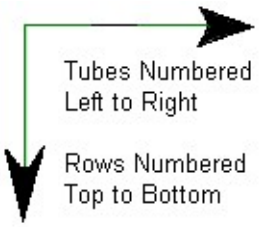
S/N 01588 #6

Opposite Inlet/Outlet



- A1 = ABN. NOMINAL BELL END
- AL = ABNORMAL LAND
- D0 = OD DEFECT < 20%
- DT = DIFFERENT TUBE TYPE
- ML = MISSING LAND
- P1 = ID PIT 20% - 39%
- P2 = ID PIT 40% - 59% REQUIRES ACTION
- PP = PREVIOUSLY PLUGGED

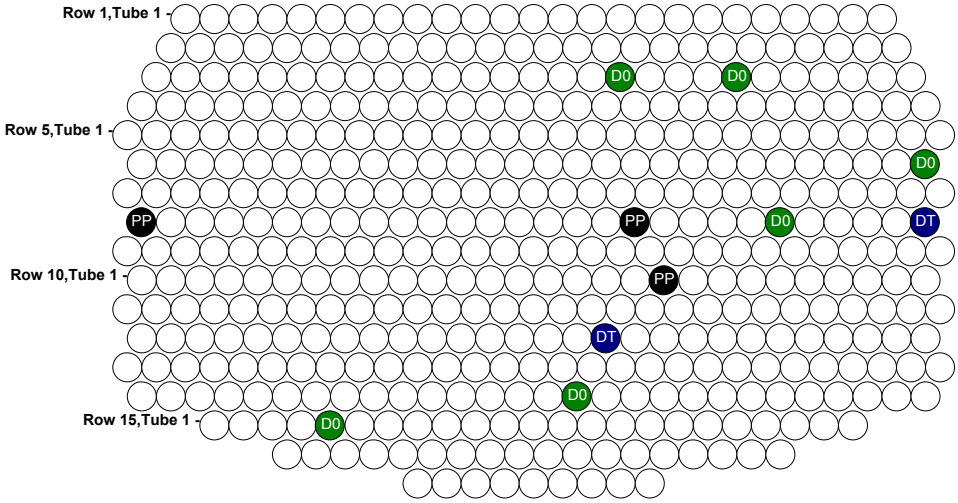
Sub-Cooler Section



Top of Vessel

S/N 01588 #6

Opposite Inlet/Outlet



D0 = OD DEFECT < 20%

DT = DIFFERENT TUBE TYPE

PP = PREVIOUSLY PLUGGED

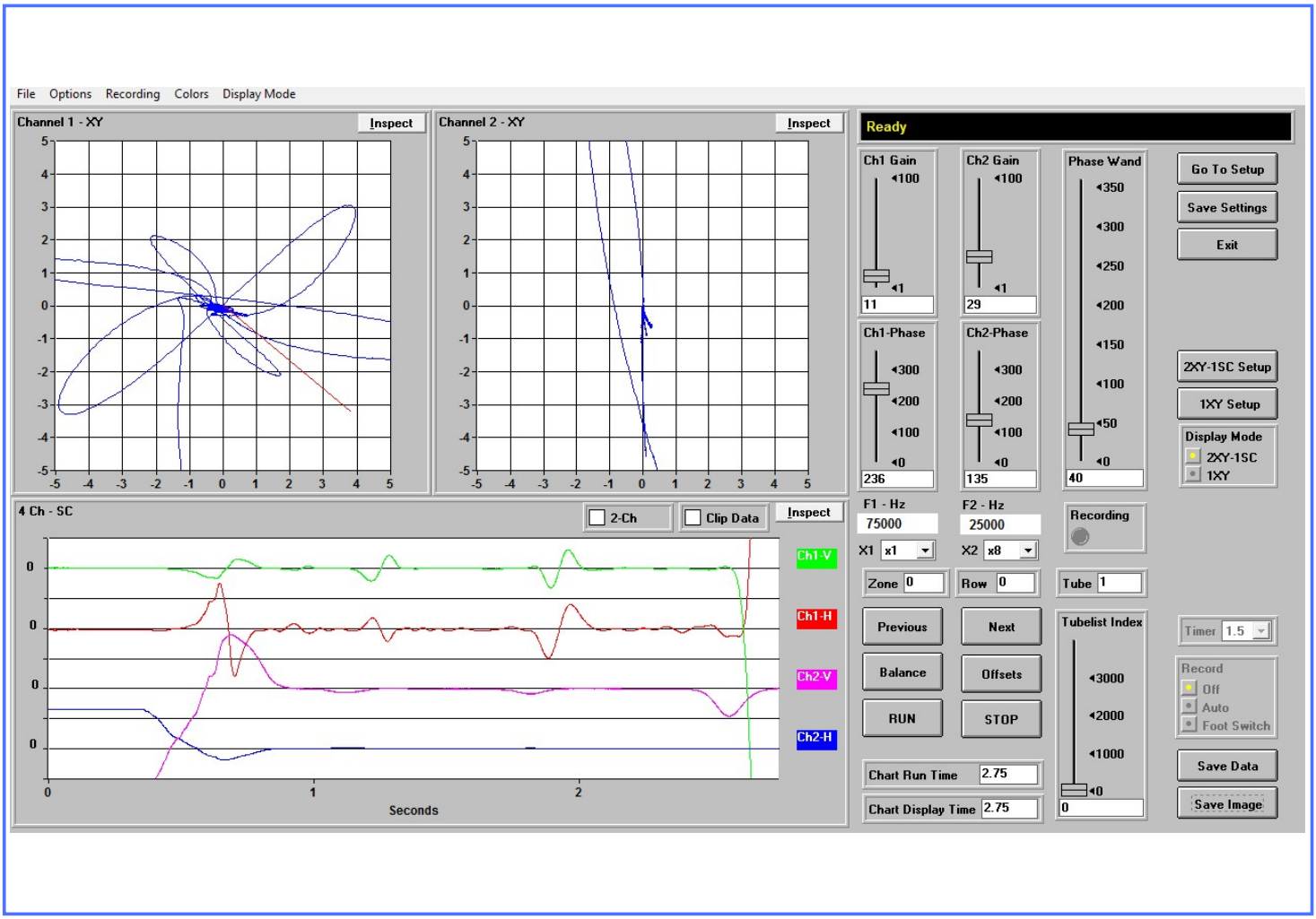
Test Instrument Used
Highline Automation, EC14

S/N 01588 #6

Calibration Page

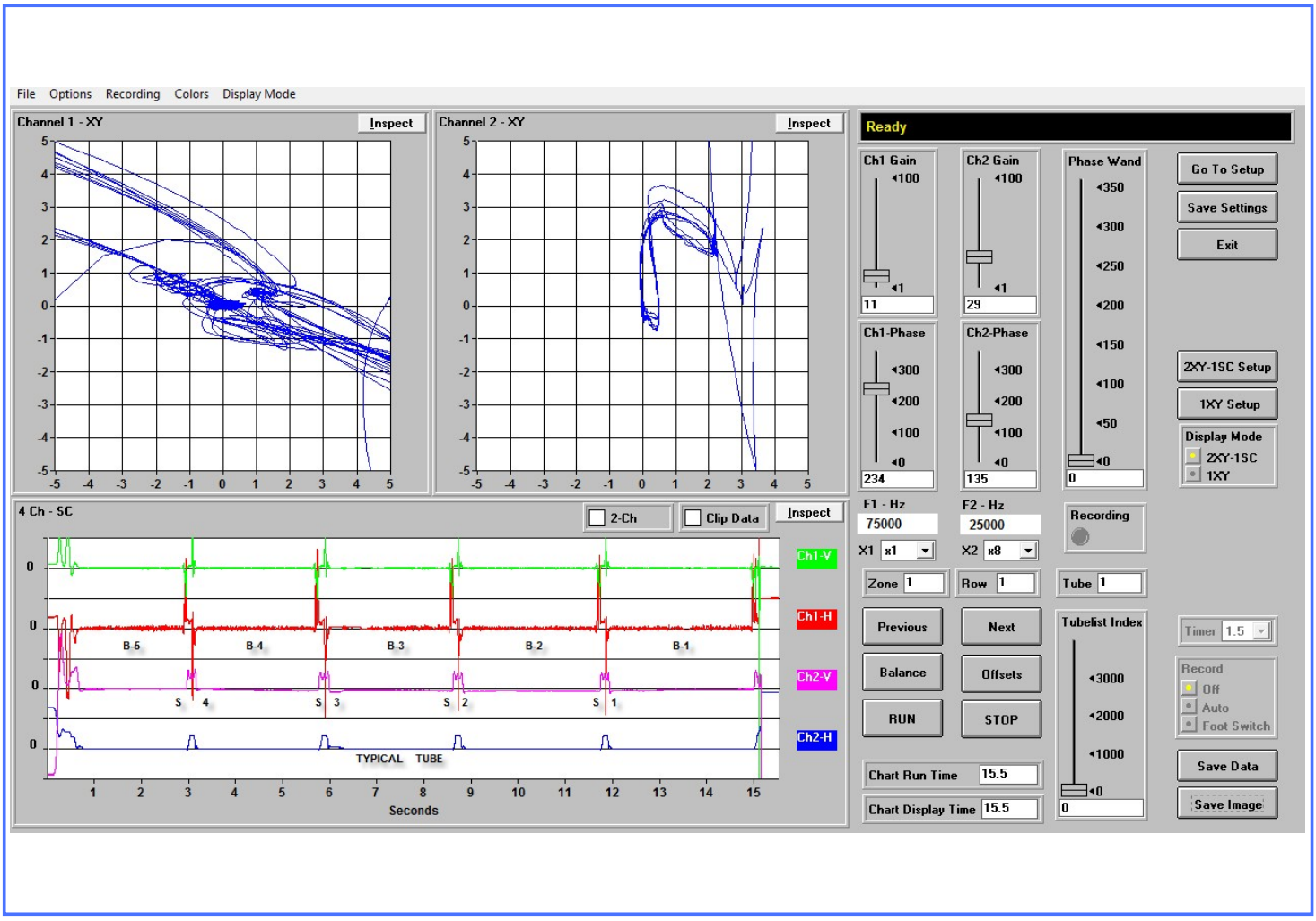
Tube Type	Material	Nom Wall Thick	End Wall Thick	OD	Test Type	Probe Diameter
Skip Fin IE	90/10 CuNi	.028	.055	.750	Cross/Diff	.5625

Condenser	Sub-Cooler



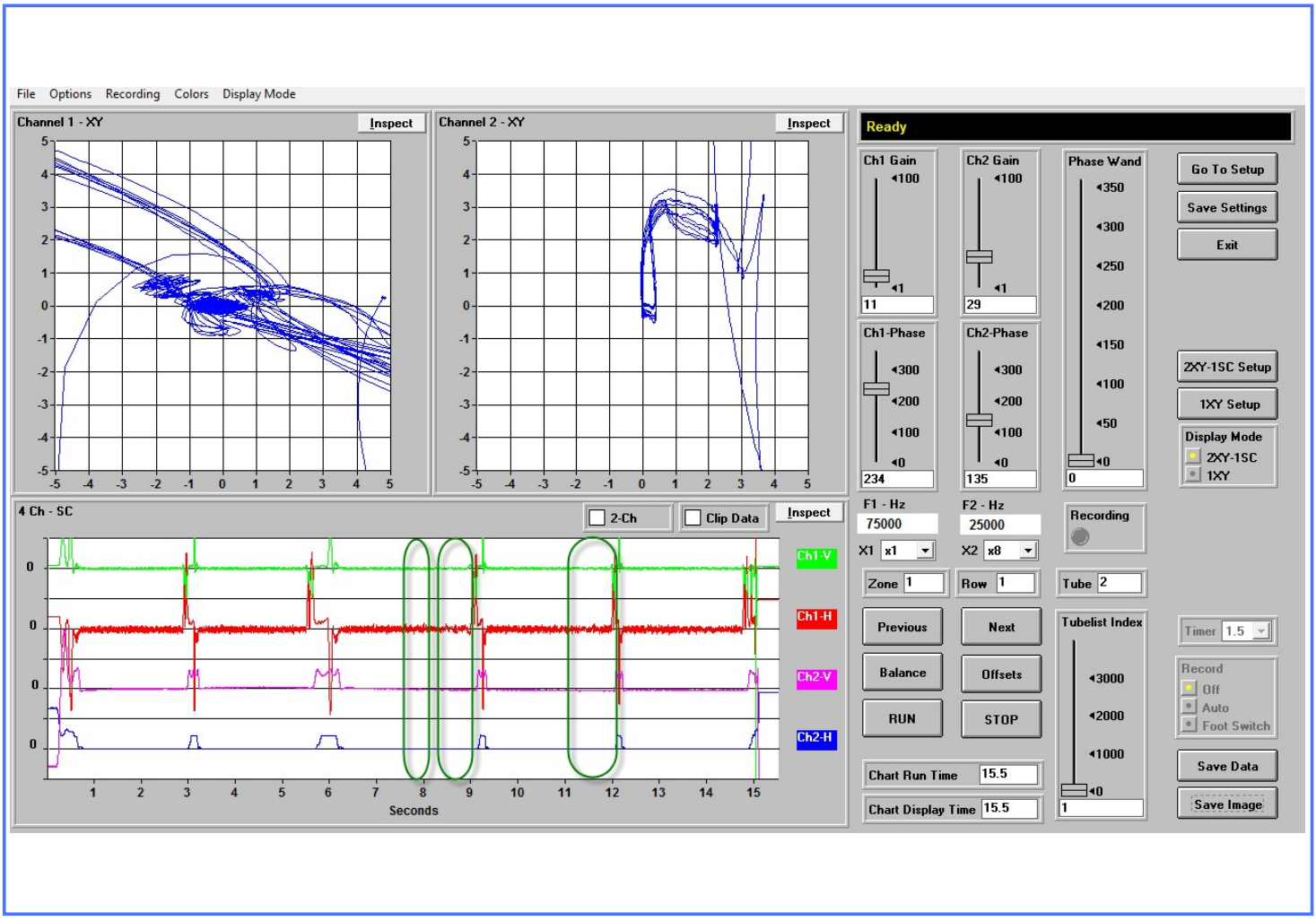
Note: Defects are compared to machined standards.
Actual Defect Geometry may differ.

Condenser Section



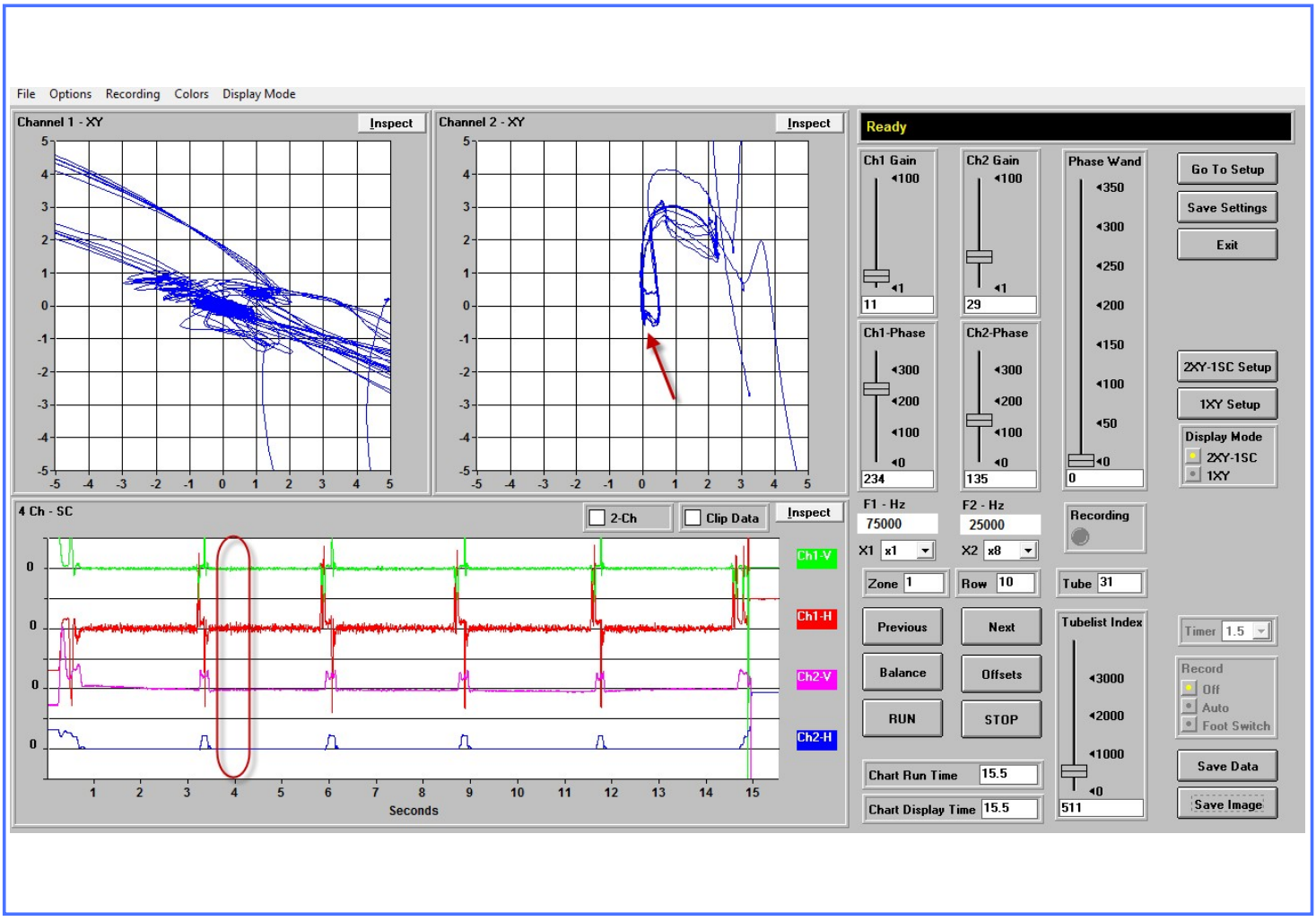
TYPICAL TUBE (Row 1 Tube 1)

Condenser Section



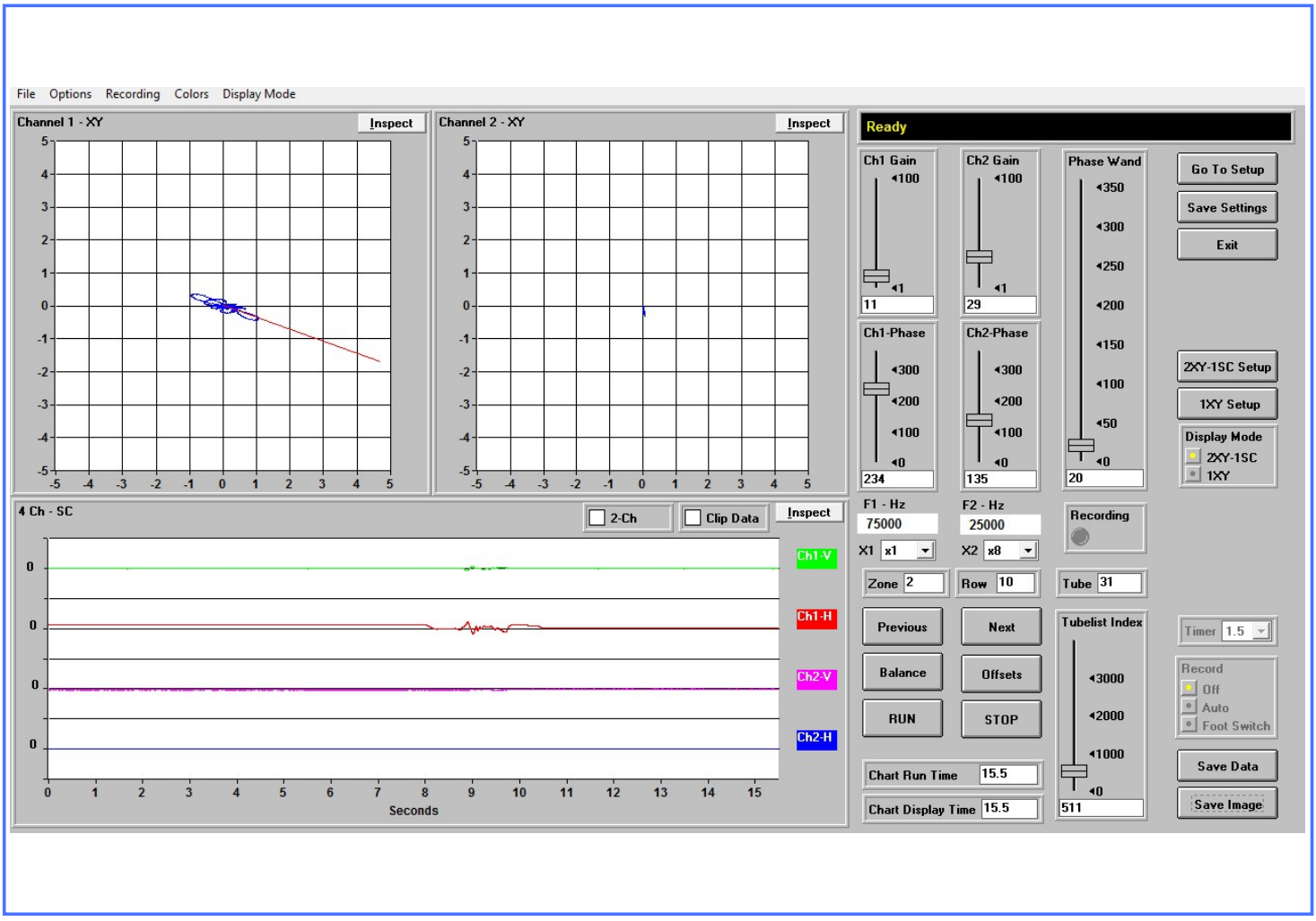
NOTED ID DAMAGE (Row 1 Tube 2)

Condenser Section



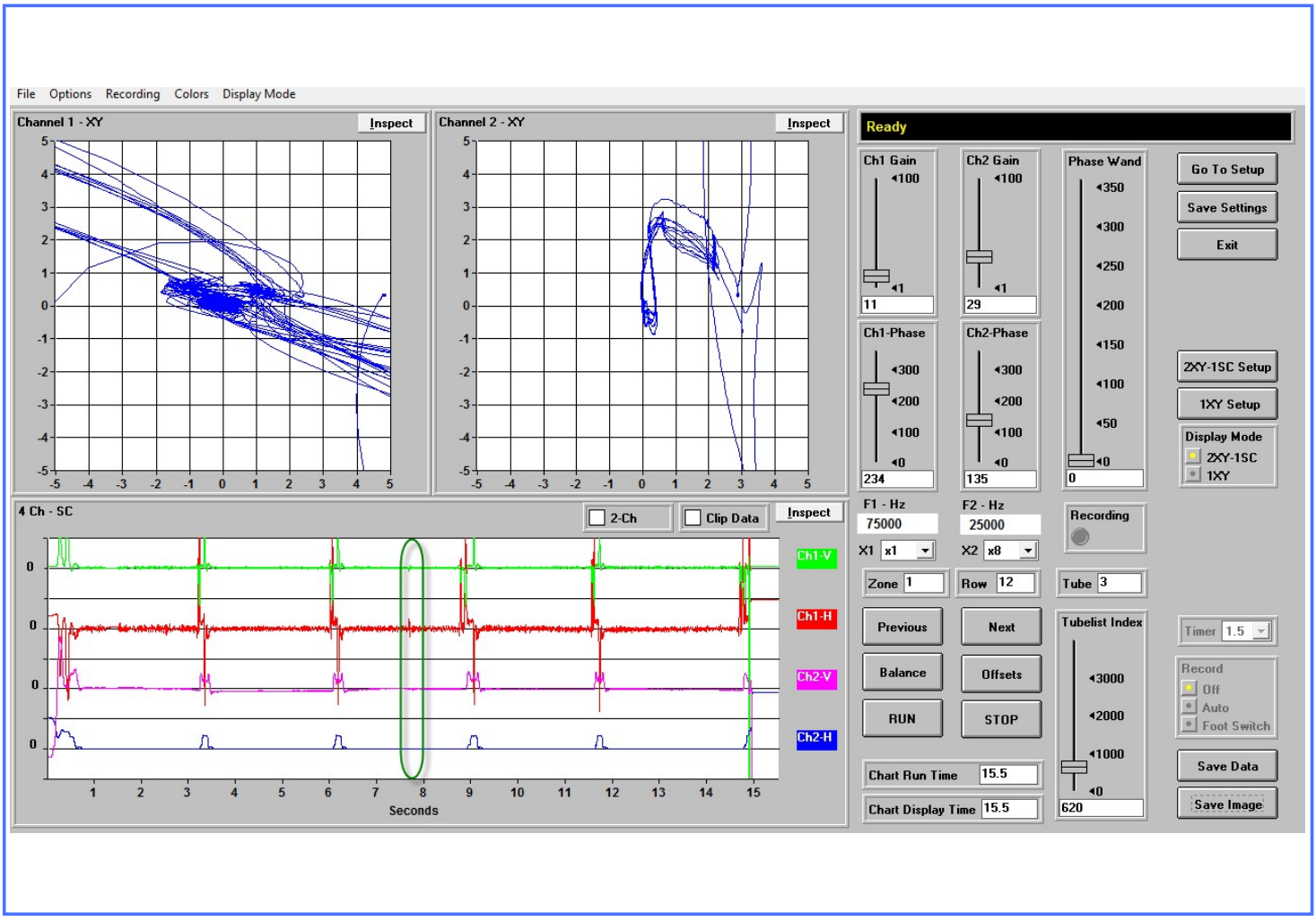
ID PIT 40% - 59% (Row 10 Tube 31)

Condenser Section



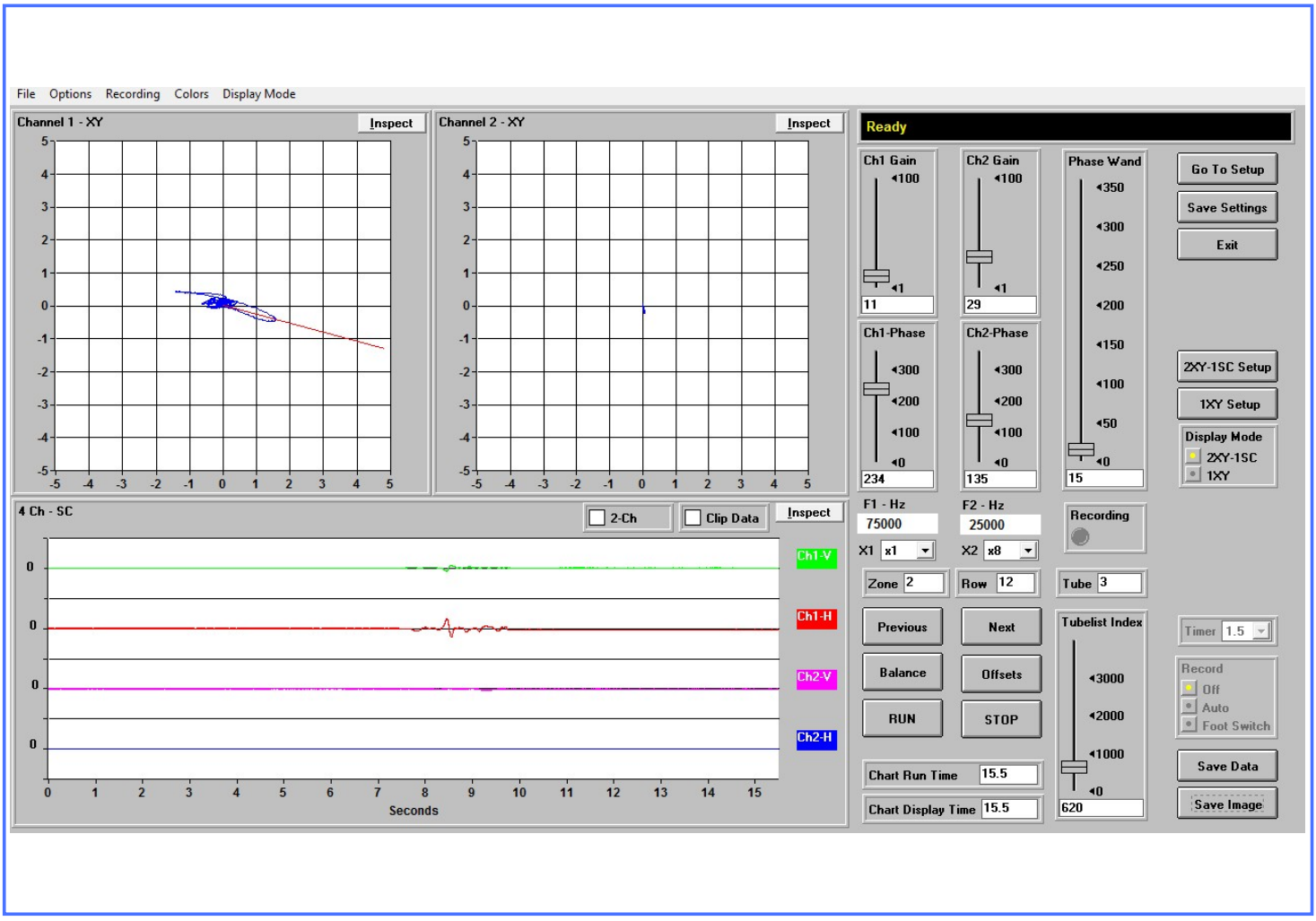
ID PIT 40% - 59% (Row 10 Tube 31)

Condenser Section



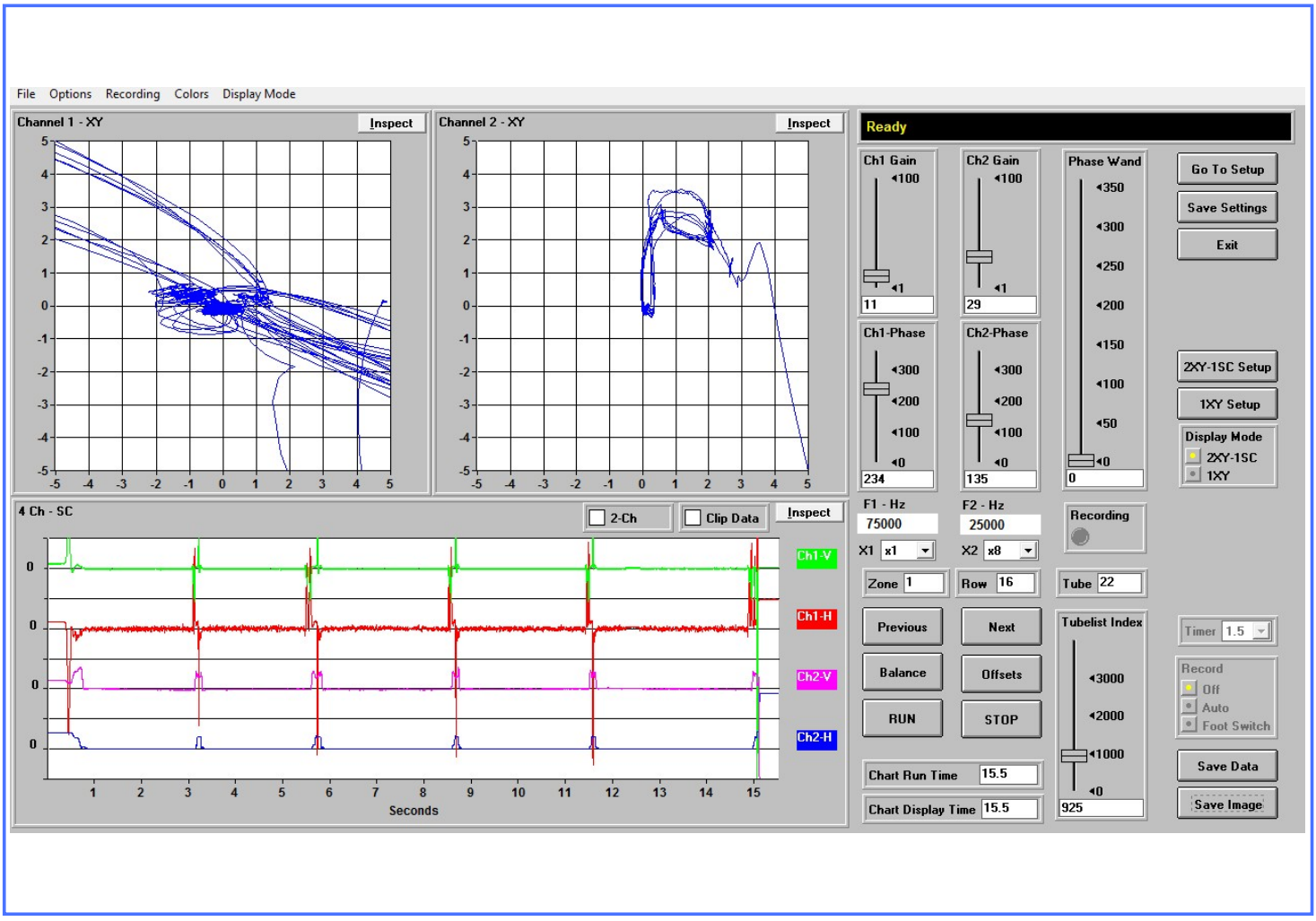
ID PIT 20% - 39% (Row 12 Tube 3)

Condenser Section



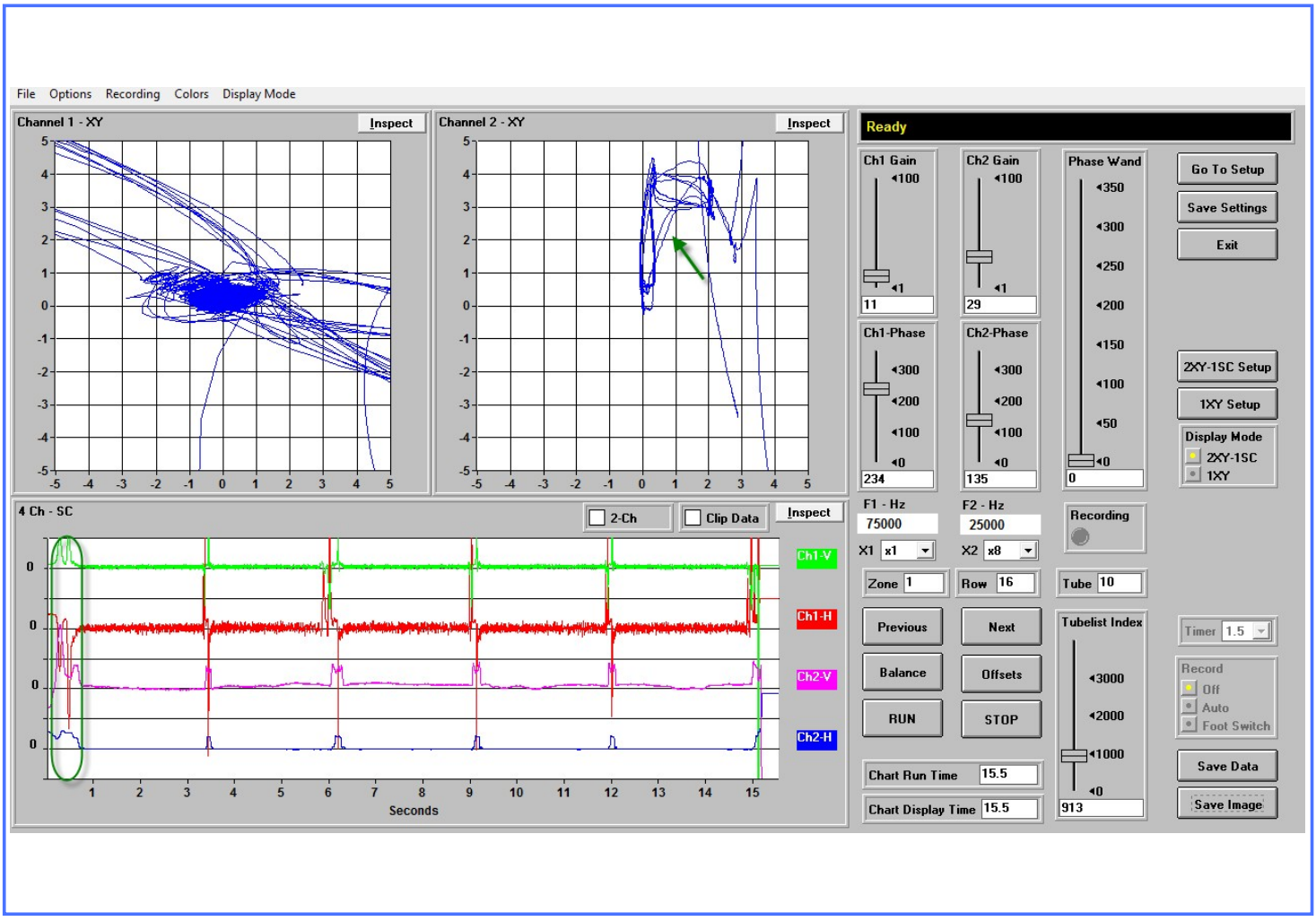
ID PIT 20% - 39% (Row 12 Tube 3)

Condenser Section



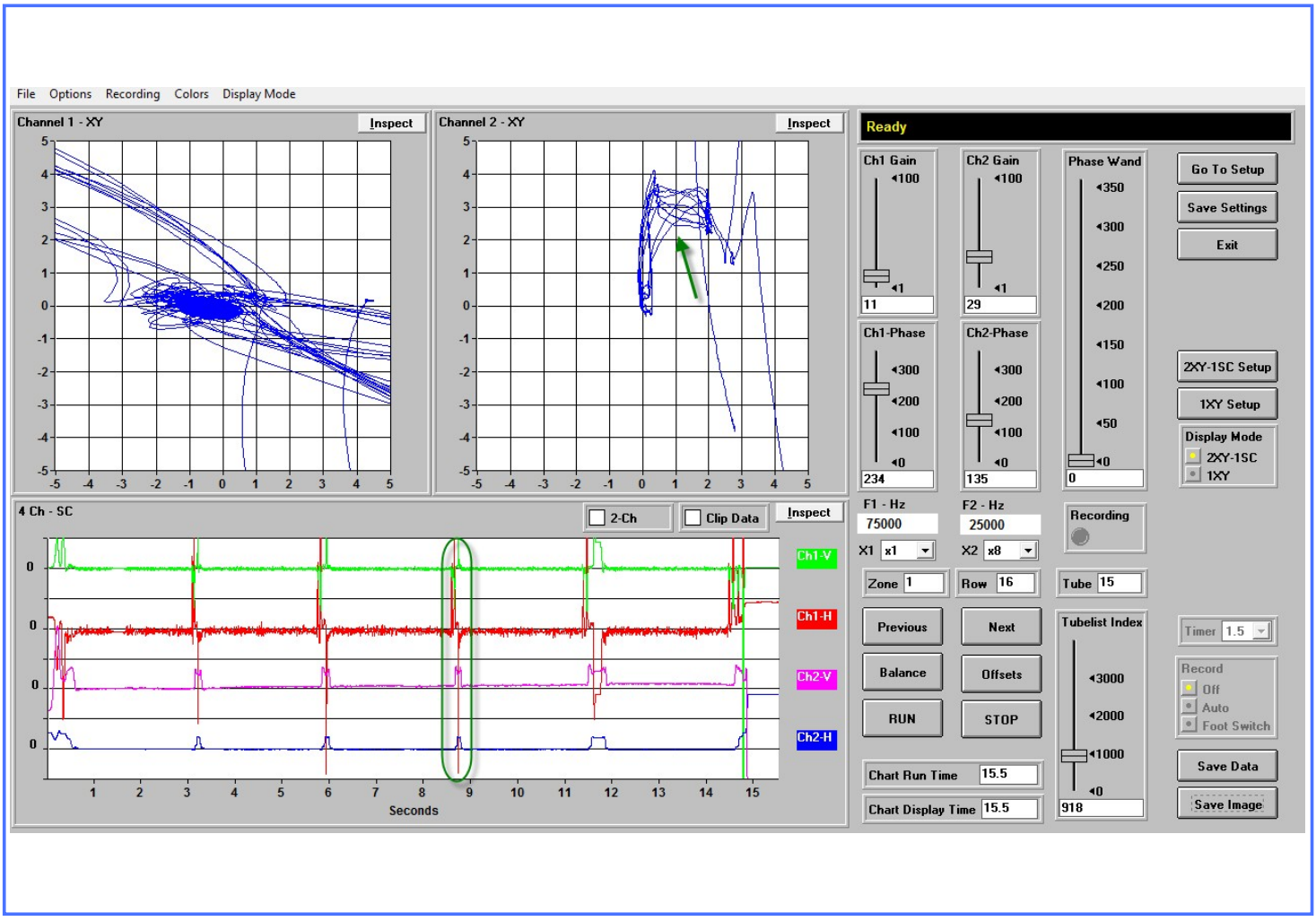
DIFFERENT TUBE TYPE (Row 14 Tube 22)

Condenser Section



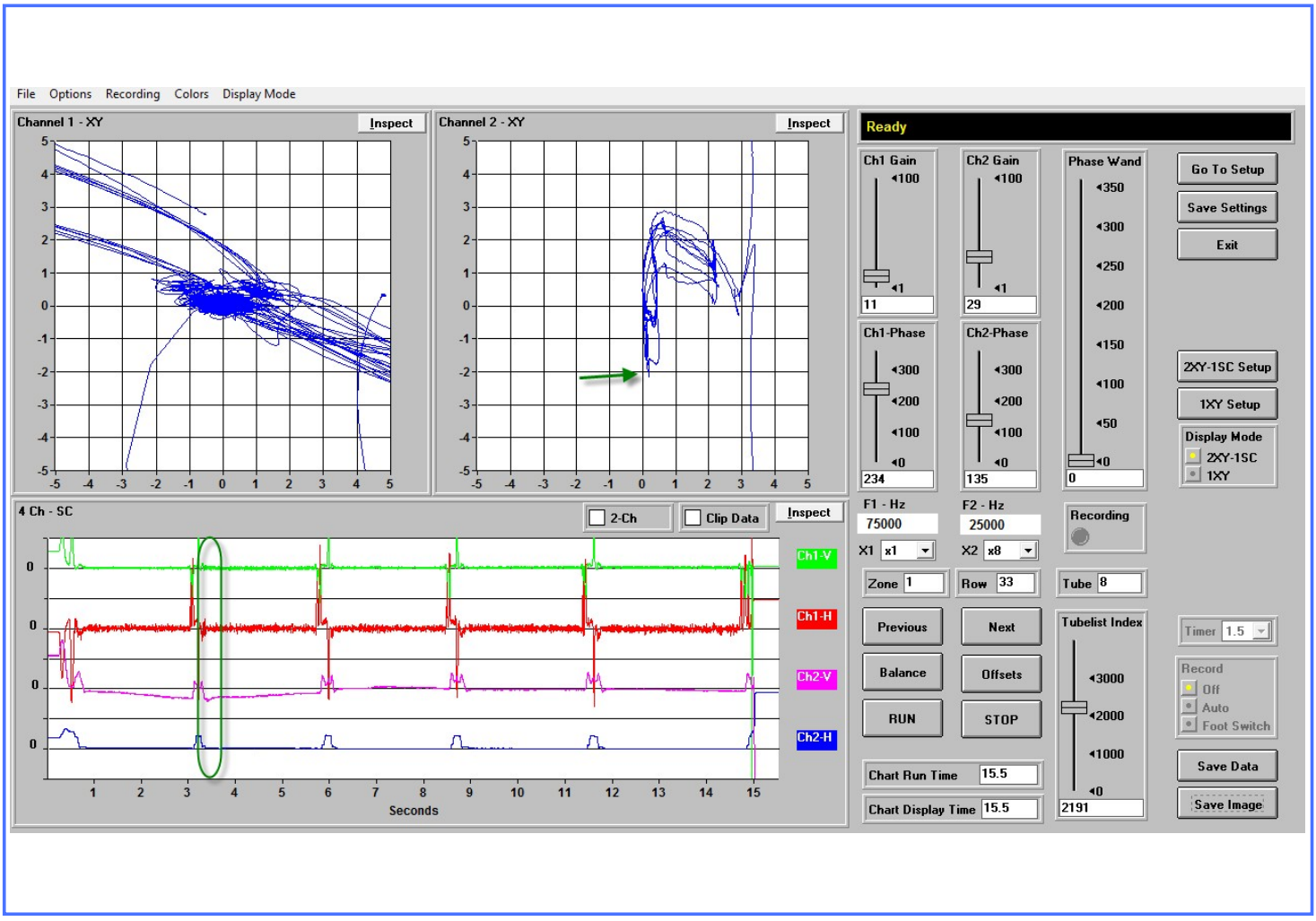
ABN. NOMINAL BELL END (Row 16 Tube 10)

Condenser Section



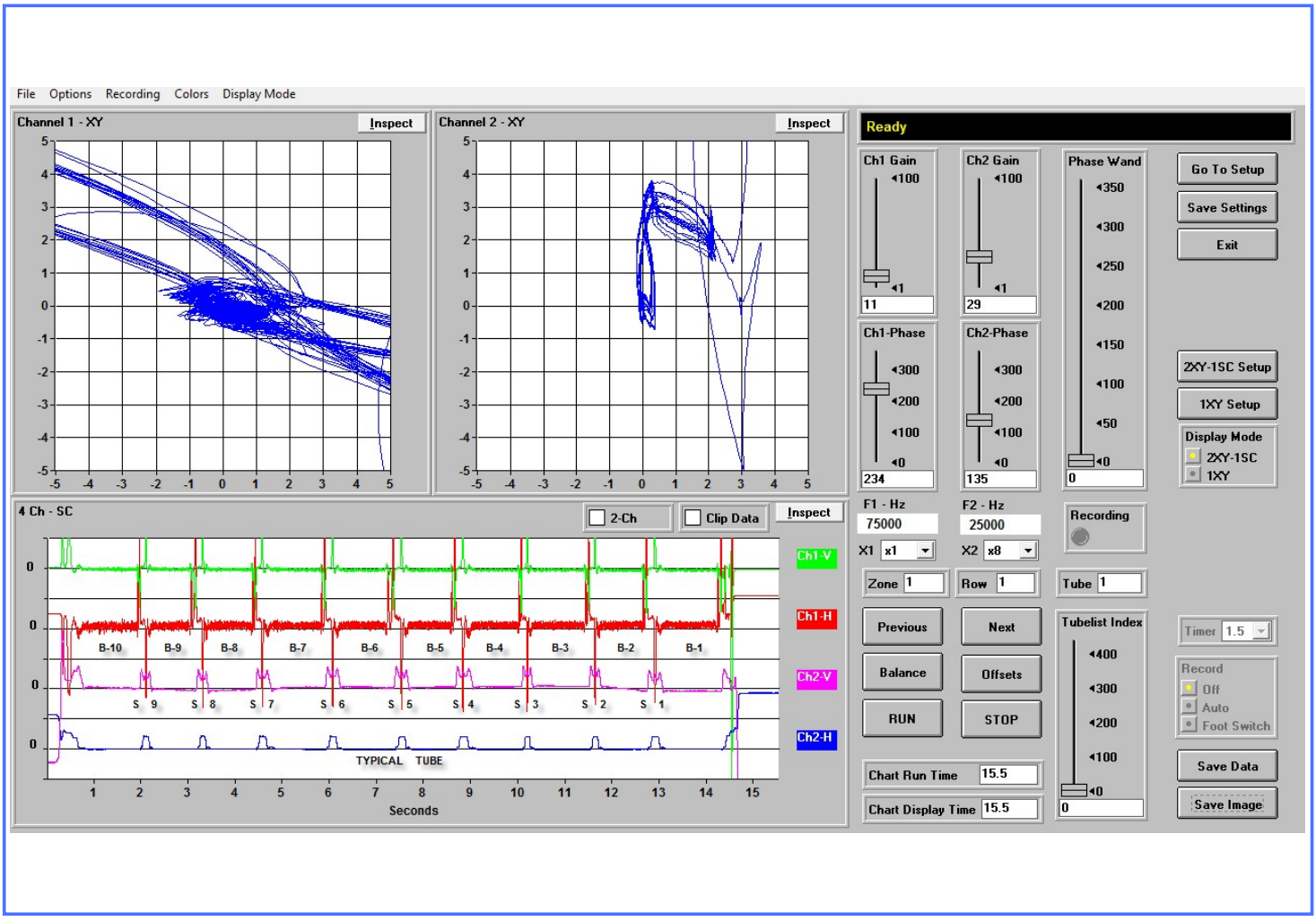
ABNORMAL LAND (Row 16 Tube 15)

Condenser Section



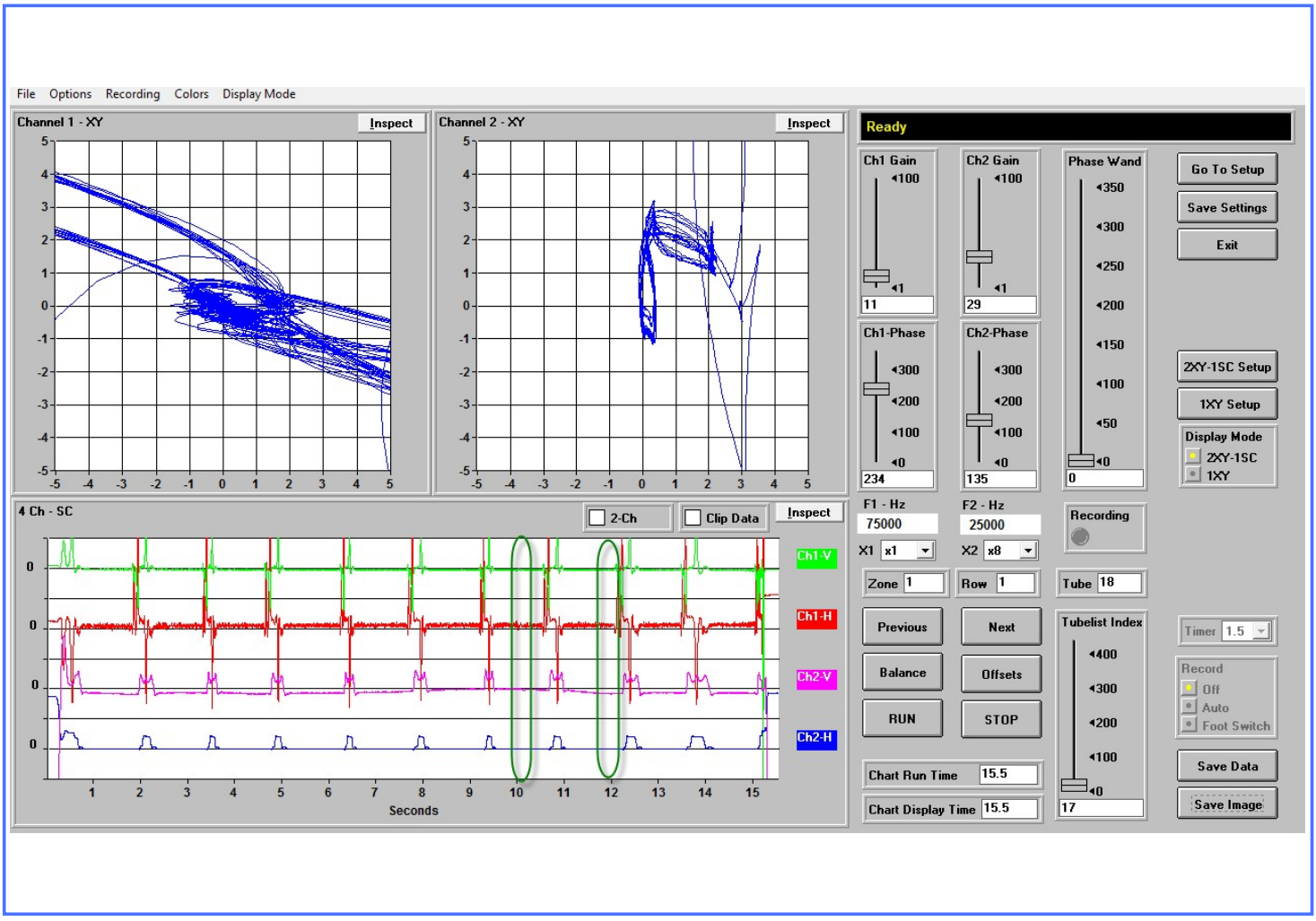
OD DEFECT < 20% (Row 33 Tube 8)

Sub-Cooler Section



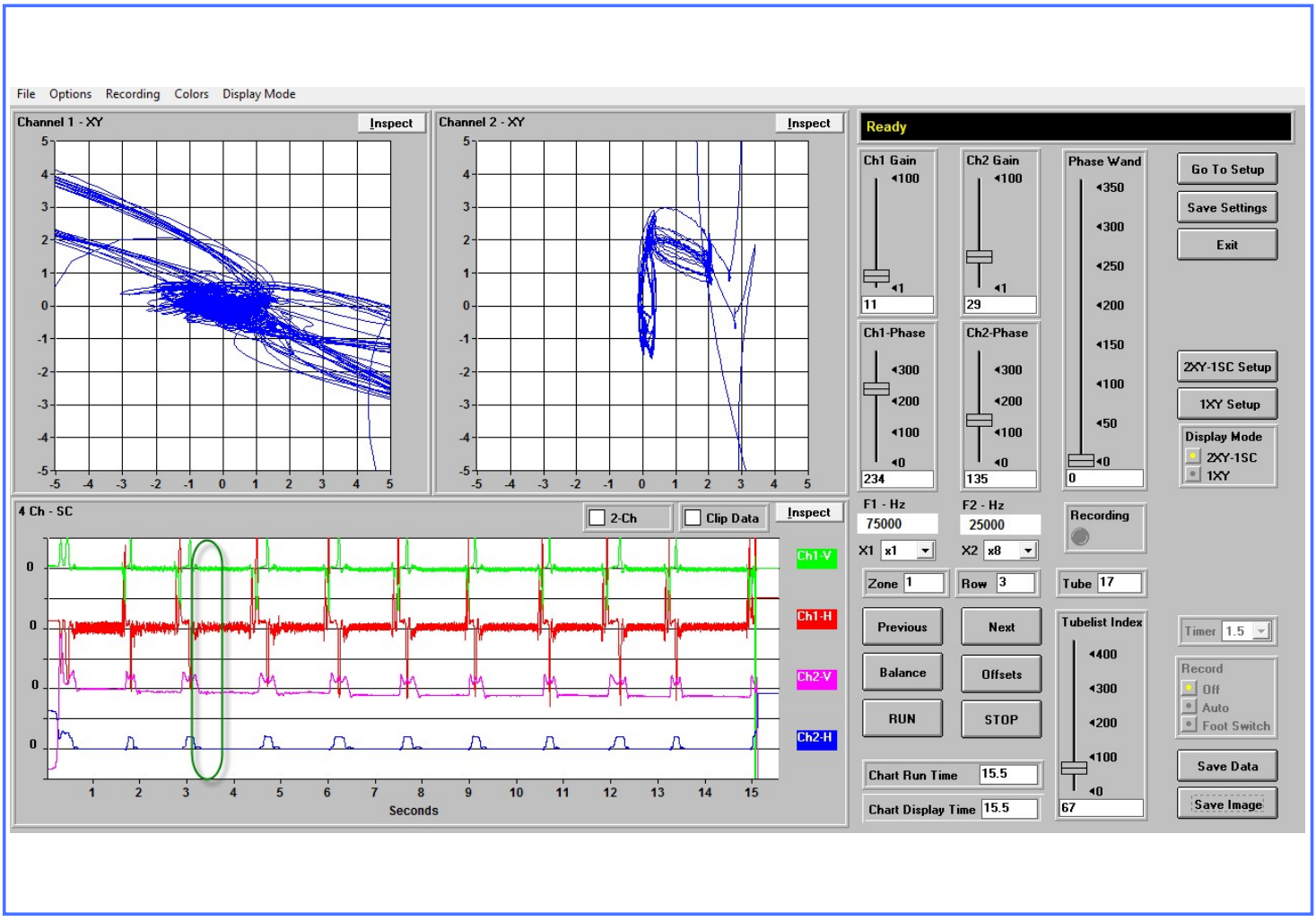
TYPICAL TUBE (Row 1 Tube 1)

Sub-Cooler Section



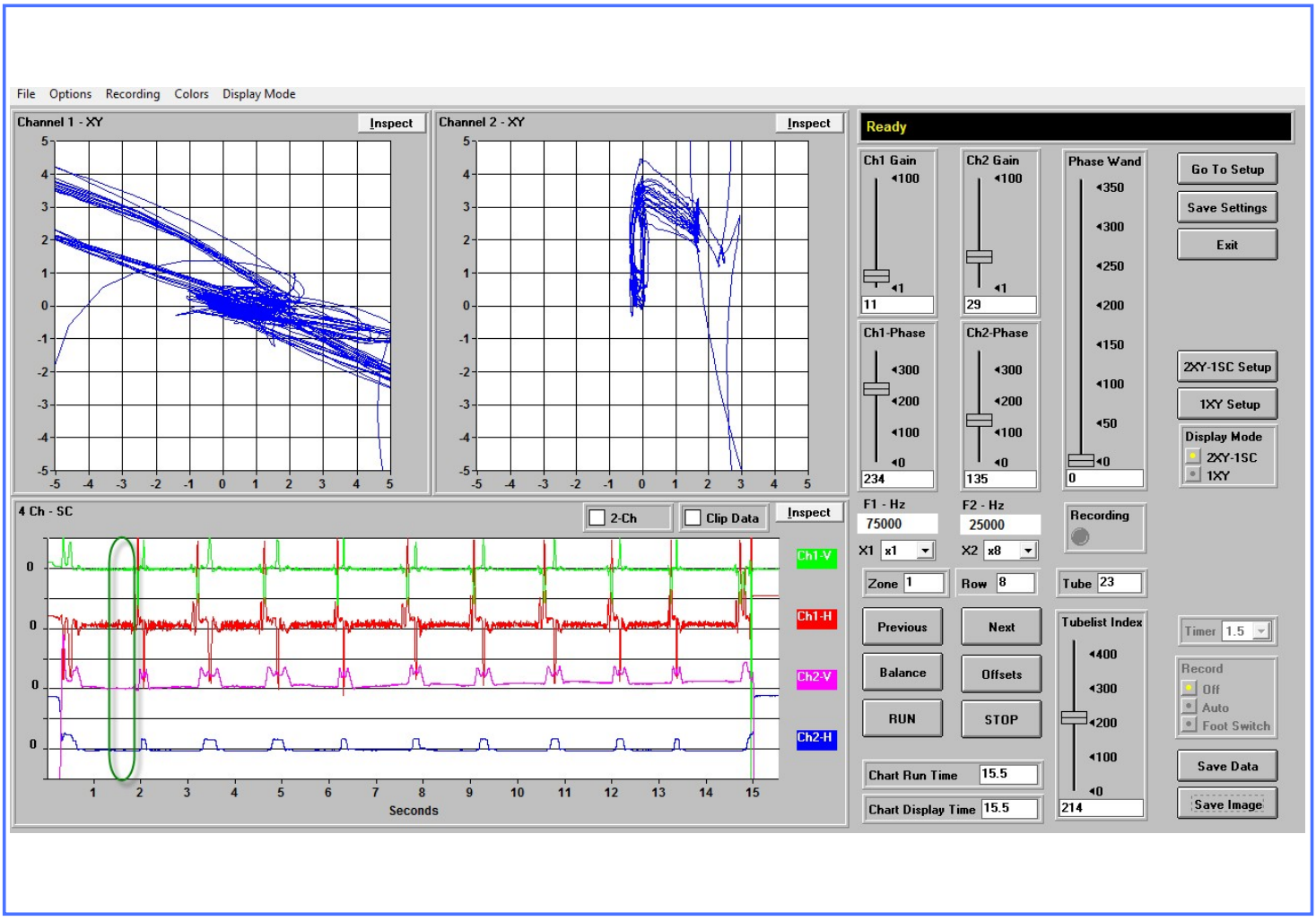
NOTED ID DAMAGE (Row 1 Tube 18)

Sub-Cooler Section



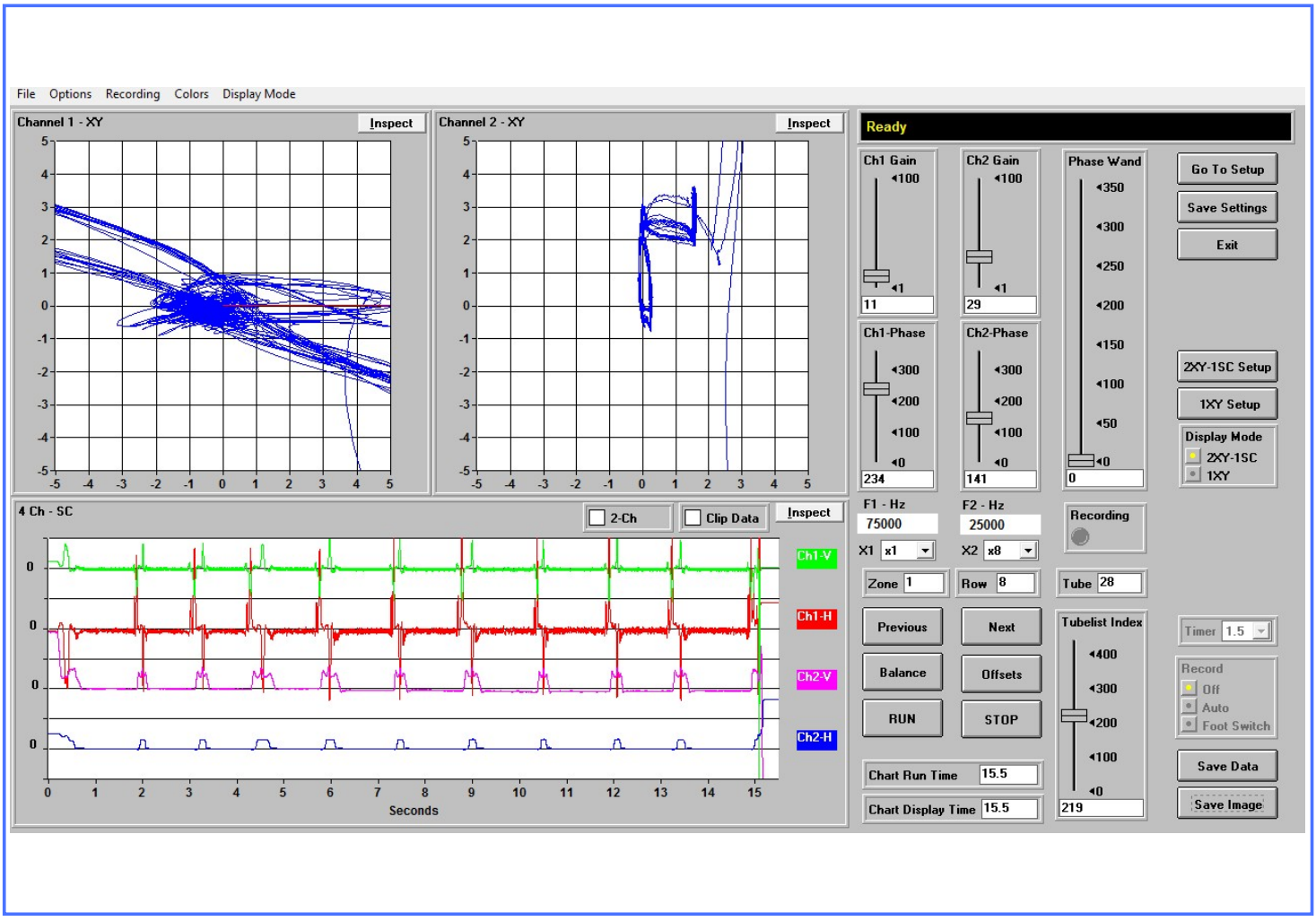
OD DEFECT < 20% (Row 3 Tube 17)

Sub-Cooler Section



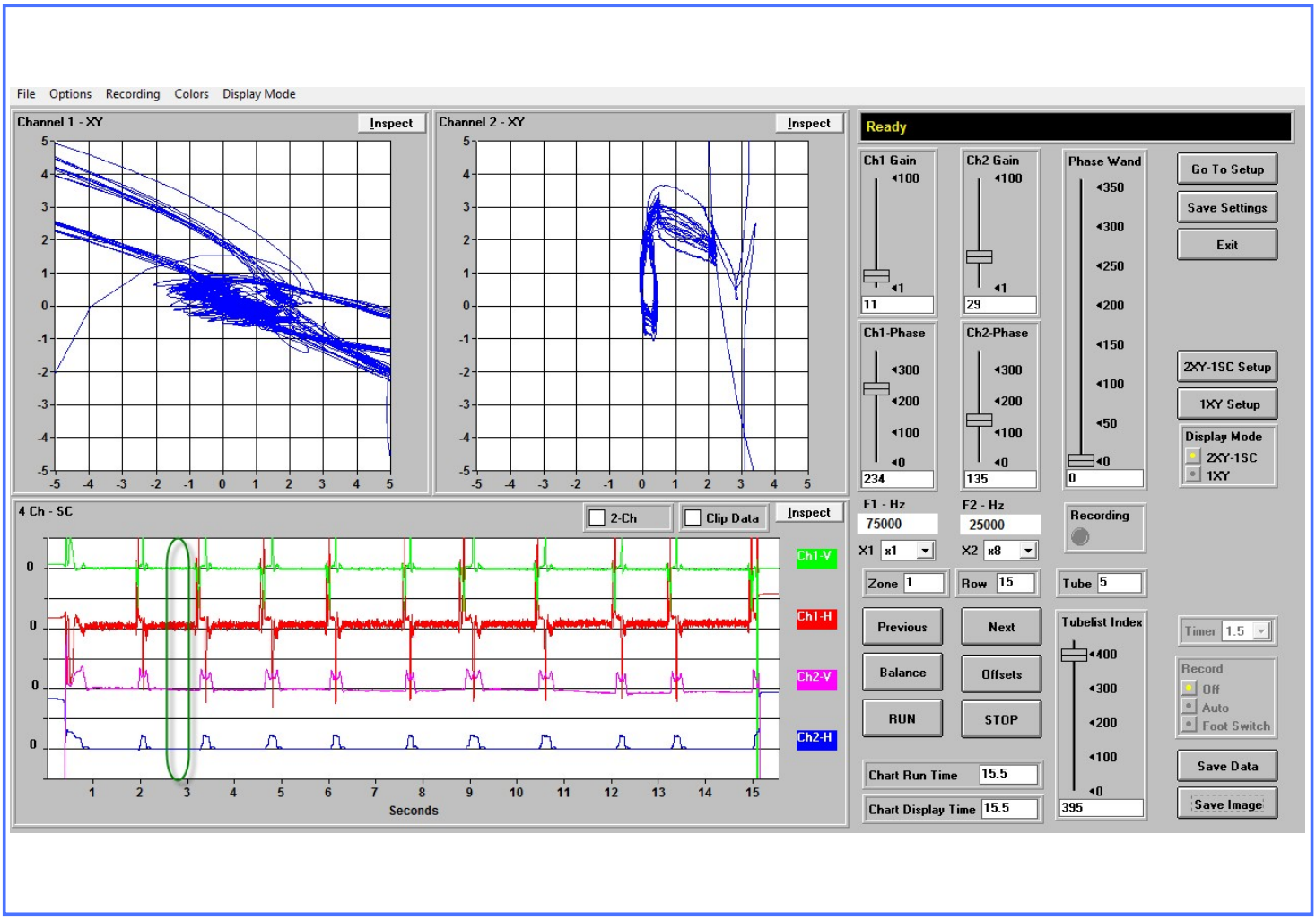
OD DEFECT < 20% (Row 8 Tube 23)

Sub-Cooler Section



DIFFERENT TUBE TYPE (Row 8 Tube 28)

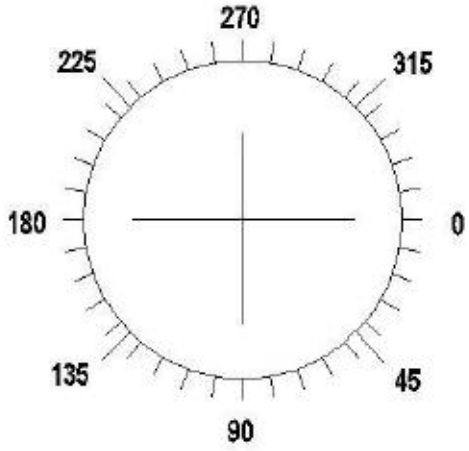
Sub-Cooler Section

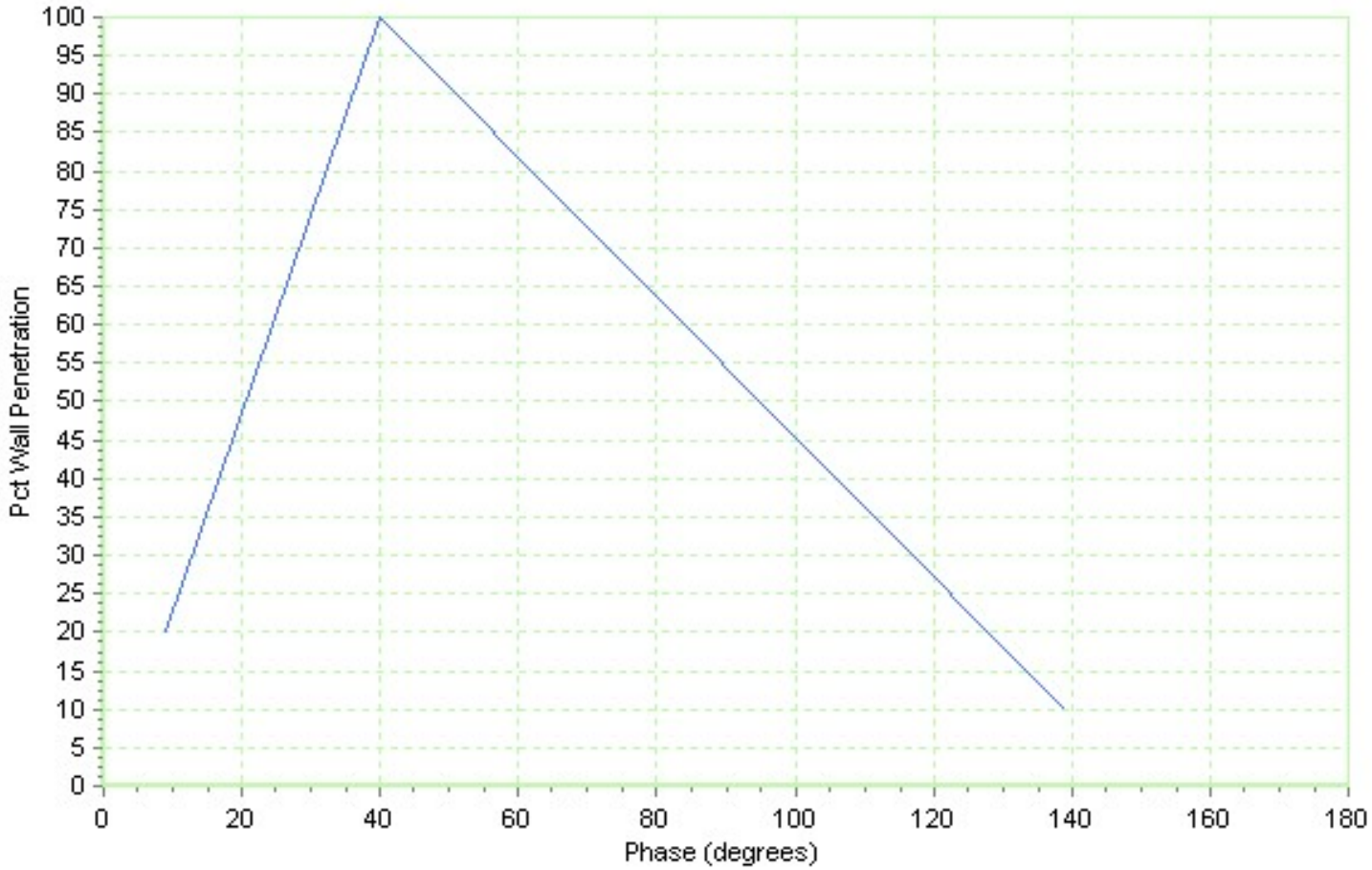


OD DEFECT < 20% (Row 15 Tube 5)

Phase Chart - Condenser

Material	Tube Type	OD	Wall	Test Type	Frequency	Probe Diameter
CuNi	Skip Fin IE	.750	.052	CROSS/DIFF	75	.5625





Calibration Procedure

A calibration procedure is performed prior to an inspection, and is repeated every 2 hours, or whenever improper operation of the test instrument is suspected. Test frequencies are selected prior to an inspection through experimentation to achieve optimum phase separation, and amplitude response for the tube type and alloy being inspected. An appropriate inspection probe is selected based on tube type, wall thickness, and alloy. The inspection probe will have a minimum fill factor of 80% through the smallest areas of the tubes being inspected. Instrument sensitivity is set high enough to determine background noise inherent in the tube and to produce a .05 Volt deflection for a .031 through wall hole at .25 V/Div.

Calibration Reference Standard

A Calibration Reference Standard representing a typical production run tube of the same alloy, tube type and nominal wall thickness is used to adjust test system response. The calibration reference standard used for the inspection of finned and internally enhanced tubing, has been milled in accordance with the American Society for Testing and Materials (ASTM). Standard Recommended Practices, E-243-80, E-426-76, and E571-76. The depth of the grooves and notches used for establishing instrument response are calculated to compensate for the influence of the fins and/or internal enhancements used on finned tubes. Where applicable, calibration reference standards are milled in accordance with the American Society of Mechanical Engineers (ASME), Section V, Article 8, Appendix I.

A strip chart recording of each calibration reference standard used for the inspection has been included in this report. Each artificial discontinuity has been identified on the strip chart recording.

Explanation of Abbreviations

Abbreviation	Explanation
ABN IND	Abnormal Indication
B	Bay
FB	Freeze Bulge
FBH	Flat Bottom Hole
FM	Foreign Material
ID	Internal Diameter
ID CORROSION	Internal Diameter, Corrosion
ID DEPOSIT	Internal Diameter, Deposit
ID PIT	Internal Diameter, Pit
IDML	Internal Diameter, Metal Loss
IE	Internally Enhanced
OD	Outside Diameter
ODML	Outside Diameter, Metal Loss
ODML@S	Outside Diameter Metal Loss at Support
OD DEPOSIT	Outside Diameter, Deposit
PLF	Possible Longitudinal Flaw
PRF	Possible Radial Flaw
PSC	Possible Stress Corrosion
S	Support
WAS	Wear at Support
>	Greater Than
<	Less Than
OTE	Opposite Test End
TE	Test End