

# **Inlet Guide Vane Monitoring System Engineering Drawings**

**Danfoss Turbocor**

Mechanical Engineering Department at the **Florida State University**

February 28, 2018

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# CONSTRUCTION DETAILS AND NOTES

THE INLET GUIDE VANE MONITORING SYSTEM CONSTRUCTION IS BROKEN UP INTO EIGHT MAIN STEPS LAID OUT AS FOLLOWS.

## DEFINITIONS:

- THE FRONT OF THE AIRFOIL IS THE SIDE WITH THE CAMERA VIEW.
- THE TOP OF THE AIRFOIL IS THE SIDE WITH THE CAMERA ENTRY.
- THE RIGHT AND LEFT OF THE AIRFOIL ARE DEFINED WHILE LOOKING DOWN THE SUCTION PIPE TOWARDS THE COMPRESSOR IN THE DIRECTION OF THE CAMERA VIEW.
- THE OUTSIDE OF EACH AIRFOIL IS THE SIDE FACING THE SUCTION PIPE WITH THE NACA PROFILE.
- THE INSIDE OF EACH AIRFOIL IS THE SIDE FACING THE MIRRORED AIRFOIL WITH THE FLAT SURFACE AND CAMERA CHANNEL.
- THE CAMERA HOUSING IS THE AREA DIRECTLY BEHIND THE SIGHT GLASS WHERE THE CAMERA HEAD VIEWS THE IGVS.

*STEPS 1 THROUGH 3 TO BE COMPLETED IN THE DANFOSS TURBOCOR MACHINE SHOP*

**STEP 1:** CONSTRUCTION OF THE PIPE CHANNEL AND ALIGNMENT HOLES ON THE INSIDE OF EACH AIRFOIL

1. MACHINE AT DANFOSS TURBOCOR MACHINE SHOP
2. START WITH TWO COPPER BLOCKS.
3. ON THE INSIDE OF THE AIRFOIL, MACHINE THE CHANNEL FOR THE PIPE WITH A BALL END MILL AS SHOWN IN THE ENGINEERING DRAWINGS.
4. DRILL THE ALIGNMENT PIN HOLES WITH A DRILL POINT MILL.

**STEP 2:** CONSTRUCTION OF NACA PROFILE ON OUTSIDE OF EACH AIRFOIL

1. MACHINE THE NACA AND CYLINDER PROFILE USING A CNC MILL WITH THE DIMENSIONS AND TOLERANCES IN THE ENGINEERING DRAWINGS.
2. MACHINE THE TOP AND BOTTOM EDGES TO A RADIUS SLIGHTLY SMALLER THAN THE INSIDE RADIUS OF THE SUCTION PIPE FOR EASE OF SOLDERING.

**STEP 3:** MACHINING OF ENTRY PIECE

1. MACHINE THE ENTRY PIECE TO THE DIMENSIONS AND TOLERANCES IN THE ENGINEERING DRAWINGS.
2. DIMENSIONS OF THIS PIECE TO BE SLIGHTLY SMALLER THAN THE AIRFOIL HOLE TO PROVIDE ROOM FOR THE SOLDER JOINT.

**STEP 4:** FIT TEST

1. TEST FIT LEFT AND RIGHT AIRFOIL ALIGNMENT WITH SLIP FIT PINS. PAY CLOSE ATTENTION TO EDGE ALIGNMENT OF ENTRY HOLE. EDGES TO BE WITHIN A 0.05MM TOLERANCE.
2. TEST FIT IN SUCTION PIPE AS ONE PIECE. AIRFOIL SHOULD BE A TIGHT FIT IN THE SUCTION PIPE AND STICK IN PLACE.

*STEPS 5 AND 6 TO BE OUTSOURCED TO PRECISION BRAZING*

**STEP 5:** ATTACHMENT OF LEFT AND RIGHT AIRFOILS

1. ALIGN THE TWO AIRFOILS TOGETHER WITH THE SLIP FIT ALIGNMENT PINS IN PLACE.
2. SOLDER THE FLAT INSIDE SURFACES OF THE AIRFOIL TOGETHER.

**STEP 6:** ATTACHMENT OF AIRFOIL TO INSIDE SURFACE OF SUCTION PIPE

1. LINE UP CENTERLINE OF AIRFOIL WITH CENTERLINE OF THE SUCTION PIPE.
2. INSERT ENTRY PIECE INTO AIRFOIL THROUGH THE TOP OF THE SUCTION PIPE.
3. SOLDER ALONG ALL JOINING SURFACES OF THE AIRFOIL, ENTRY PIECE AND SUCTION PIPE.

*STEPS 7 THROUGH 12 TO BE COMPLETED IN THE DANFOSS TURBOCOR MACHINE SHOP*

**STEP 7:** FABRICATION OF SIGHT GLASS AND CAMERA HEAD CASING ON FRONT OF AIRFOIL

1. DRILL, BORE AND REAM THE HOLE FOR THE CAMERA.
2. DRILL, BORE AND REAM THE HOLE FOR THE SIGHT GLASS.

**STEP 8:** FINISH AND POLISH THE BRASS AIRFOIL

1. DEBUR ANY ROUGH EDGES.
2. RINSE BRASS WITH SOAP AND WATER.
3. POLISH WITH BRASS CLEANER.
4. BUFF BRASS TO SHINY FINISH.

**STEP 9:** CUT HOLE IN SUCTION PIPE WITH CNC MILL TO DIMENSIONS AND TOLERANCES IN ENGINEERING DRAWINGS

**STEP 10:** ATTACHMENT AND SEAL OF SIGHT GLASS

1. TEST THE SEALANT FOR REFRIGERANT COMPATIBILITY PRIOR TO USE.
2. ROUGH THE EDGES OF THE SIGHT GLASS AND THE INSIDE OF THE SIGHT GLASS HOUSING IN THE AIRFOIL FOR SEALANT TO SEEP INTO.
3. APPLY THIN LAYER OF SEALANT TO OUTSIDE CURVED SURFACE OF SIGHT GLASS ONLY.
4. INSERT SIGHT GLASS INTO HOUSING WHILE TWISTING TO GIVE SEALANT CONTACT ACROSS ENTIRE CURVED SURFACE OF HOUSING AND SIGHT GLASS.
5. CLAMP THE SIGHT GLASS INTO ITS HOUSING OR HOLD TIGHTLY IN PLACE TO PREVENT SEALANT FROM FLOWING INTO CAMERA HOUSING. THIS IS MEANT TO CREATE A GLASS TO BRASS SEAL ON THE BACK SURFACE OF THE SIGHT GLASS.
6. APPLY EXTRA SEALANT AROUND CIRCUMFERENCE OF SIGHT GLASS LETTING THE SEALANT FILL AROUND THE GLASS. WIPE OFF FRONT OF GLASS.
7. USE MINIMAL AMOUNT OF SEALANT SO OVERFLOW DOES NOT ENTER THE CAMERA HOUSING.

**STEP 12:** LIGHTING SUBSYSTEM TO FOLLOW

**STEP 13:** PERFORM PRESSURE TEST

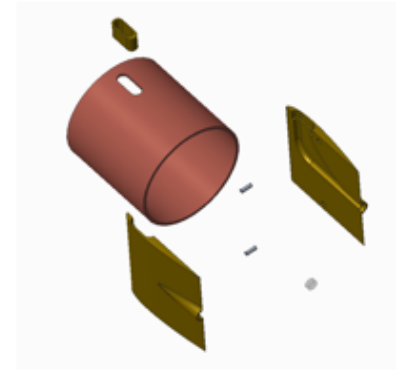
1. ATTACH FLANGE CONNECTION TO FRONT END OF MONITORING SYSTEM AND CONNECT TO TEST STAND.
2. BRING PRESSURE IN PIPE UP TO 300 PSI FOR 10 MINUTES AND PERFORM LEAK TEST TO ENSURE NO LEAKAGE INTO THE ATMOSPHERE BEFORE INTRODUCTION OF REFRIGERANT.

*FINAL STEP 13 COMPLETED BY SENIOR DESIGN TEAM IN CONJUNCTION WITH DANFOSS TURBOCOR TESTING LAB*

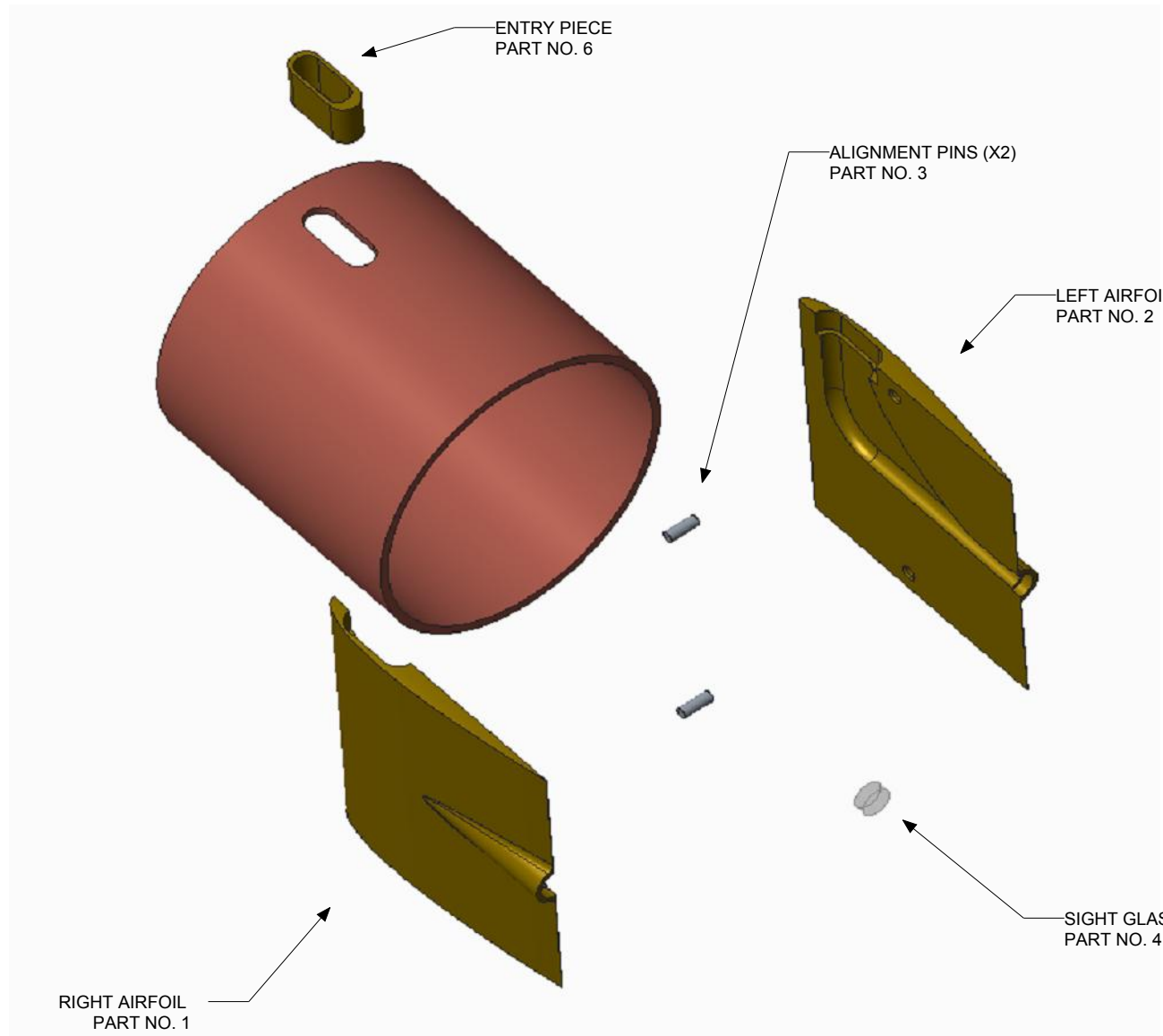
**STEP 13:** HOOK UP CAMERA SYSTEM TO TESTING AND MONITORING EQUIPMENT

## BILL OF MATERIALS

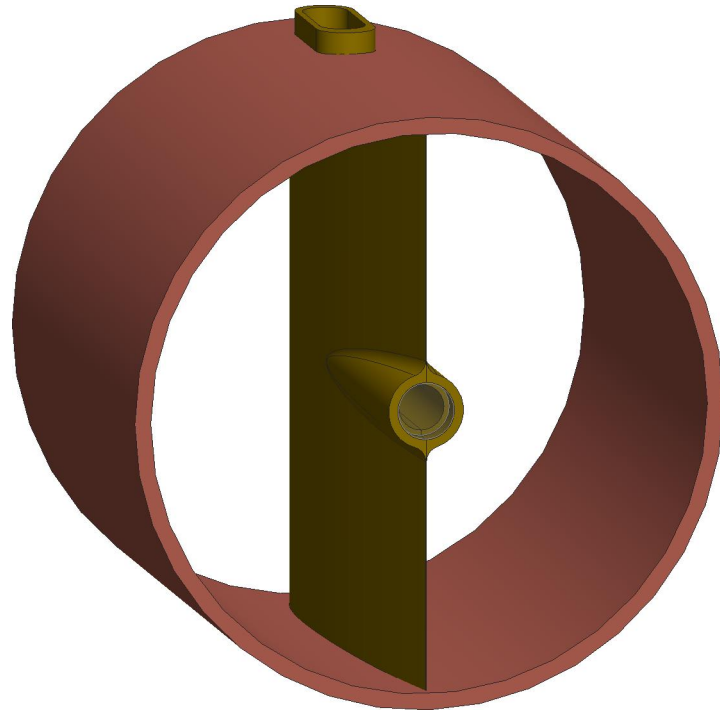
**Assembly Name:** IGV Monitoring System  
**Review Date:** Wednesday, February 28, 2018  
**Assembly Revision:** 3  
**Part Count:** 9  
**Total Material Cost:** \$1,370.92



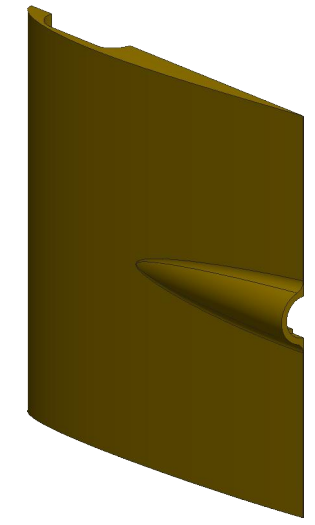
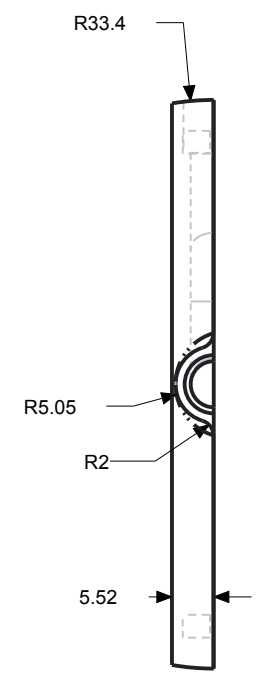
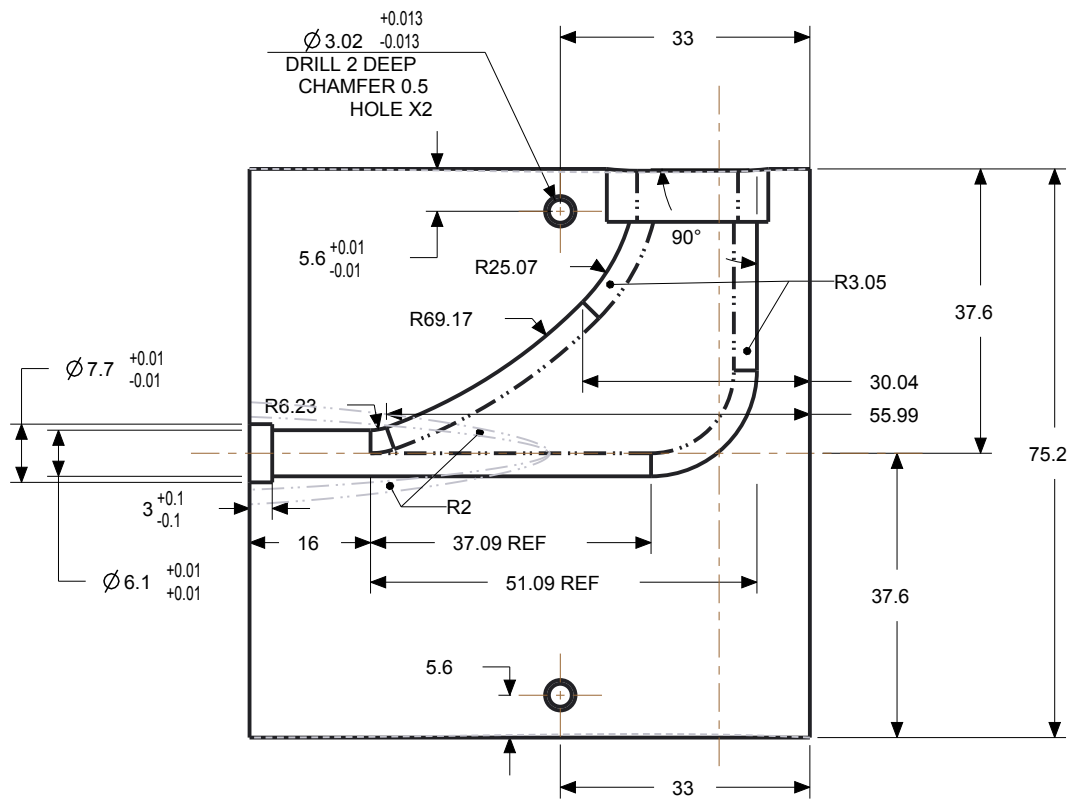
Part #	Part Name	Description	Qty	Supplier	Material	Cost per Item	Estimated Total Cost
1	Right Airfoil	The left side of the airfoil casing to house the camera	1	Danfoss Turbocor	Brass	\$53.00	\$53.00
2	Left Aifoil	The right side of the airfoil casing to house the camera. Mirrored version of the right airfoil	1	Danfoss Turbocor	Brass	\$53.00	\$53.00
3	Alignment Pin	3x8mm pins to align the two airfoil halves	2	Danfoss Turbocor	Steel	\$0.00	\$0.00
4	Sight Glass	7.5x3mm glass cut with a diamond drill bit and smoothed to fit copper housing in airfoil	1	Senior Design Team	Glass	\$0.00	\$0.00
5	Suction Pipe	Suction pipe with flange connection to attach to the inlet of the TT-series oil free compressor	1	Danfoss Turbocor	Brass	\$0.00	\$0.00
6	Entry Piece	Insertion piece for surface area increase at camera point of entry	1	Danfoss Turbocor	Brass	\$20.00	\$20.00
7	Videoscope	Exttech HDV540 High Definition Videoscope	1	Exttech	Misc.	\$1,200.00	\$1,200.00
8	Sealant	High-Strenth Silicone Sealants Model RTV157 from McMaster-Carr	1	Danfoss Turbocor	Sealant	\$44.92	\$44.92
<b>Total:</b>			<b>9</b>	<b>Estimated Total Material Cost:</b>		<b>\$1,370.92</b>	



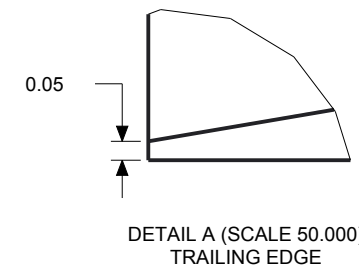
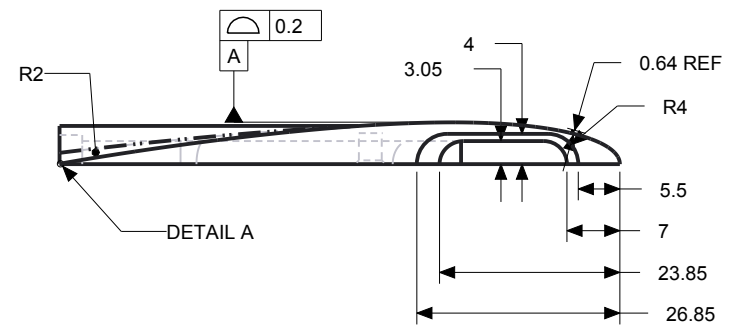
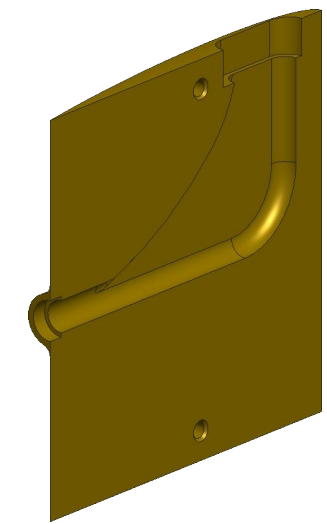
ASSEMBLY PARTS LIST		INLET GUIDE VANE MONITORING SYSTEM		
	UNITS: MM	COMPANY SPONSOR	DEPARTMENT OF MECHANICAL ENGINEERING	SPONSOR
TOLERANCE	TOOL USED	DANFOSS TURBOCOR	FLORIDA STATE UNIVERSITY	WILLIAM BILBOW
N/A	N/A	PROJECT COMPLETION	DRAWINGS REVIEWED	DESIGNER
PART NAME	MATERIAL	MAY 4, 2018	FEBRUARY 28, 2018	PETER HOUSE
EXPLODED VIEW	COPPER	SCALE (NTS)	SENIOR DESIGN TEAM 4	SHEET 3 OF 10



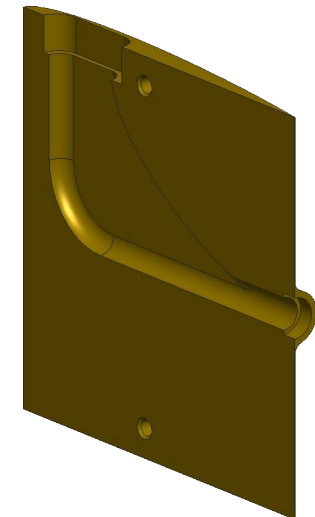
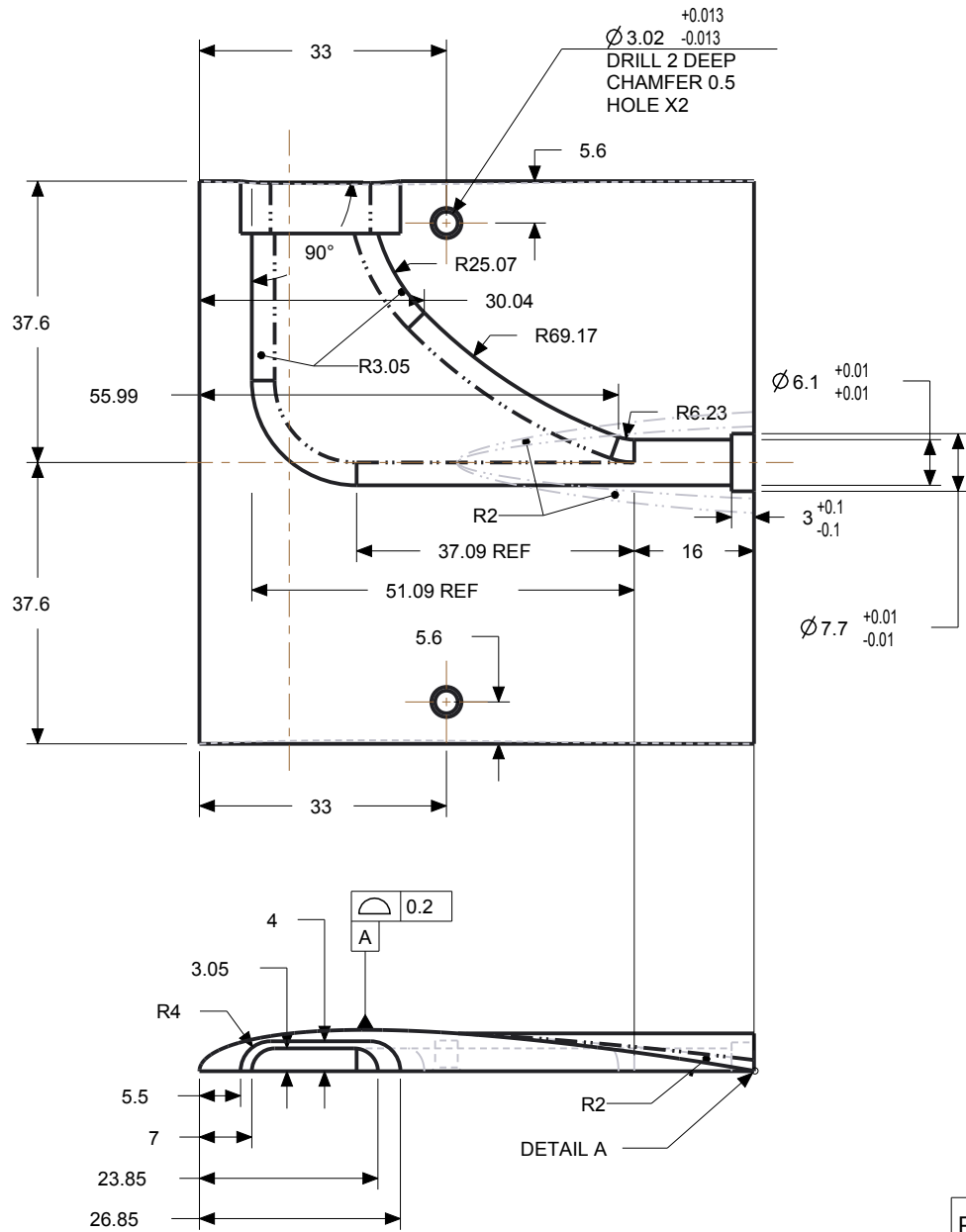
COMPLETED ASSEMBLY		INLET GUIDE VANE MONITORING SYSTEM		
	UNITS: MM	COMPANY SPONSOR	DEPARTMENT OF MECHANICAL ENGINEERING	SPONSOR
TOLERANCE	TOOL USED	DANFOSS TURBOCOR	FLORIDA STATE UNIVERSITY	WILLIAM BILBOW
N/A	N/A	PROJECT COMPLETION	DRAWINGS REVIEWED	DESIGNER
PART NAME	MATERIAL	MAY 4, 2018	FEBRUARY 28, 2018	PETER HOUSE
ASSEMBLY	N/A	SCALE (1.00)	SENIOR DESIGN TEAM 4	SHEET 4 OF 10



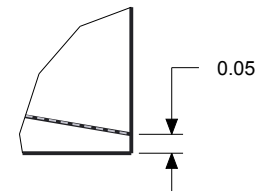
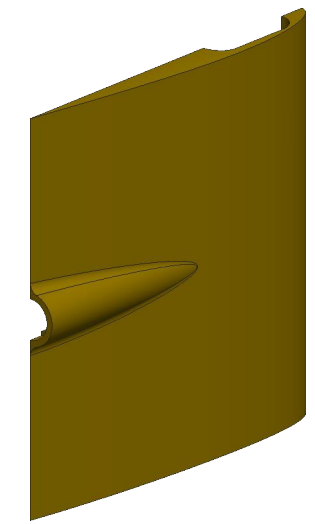
SCALE 0.750



PROJECT STEPS 1-8		INLET GUIDE VANE MONITORING SYSTEM		
UNITS: MM		COMPANY SPONSOR	DEPARTMENT OF MECHANICAL ENGINEERING	SPONSOR
TOLERANCE	TOOL USED	DANFOSS TURBOCOR	FLORIDA STATE UNIVERSITY	WILLIAM BILBOW
(± 0.05)	CNC MILL	PROJECT COMPLETION	DRAWINGS REVIEWED	DESIGNER
PART NAME (NO. 1)	MATERIAL	MAY 4, 2018	FEBRUARY 28, 2018	PETER HOUSE
RIGHT AIRFOIL	BRASS	SCALE (1.00)	SENIOR DESIGN TEAM 4	SHEET 5 OF 10



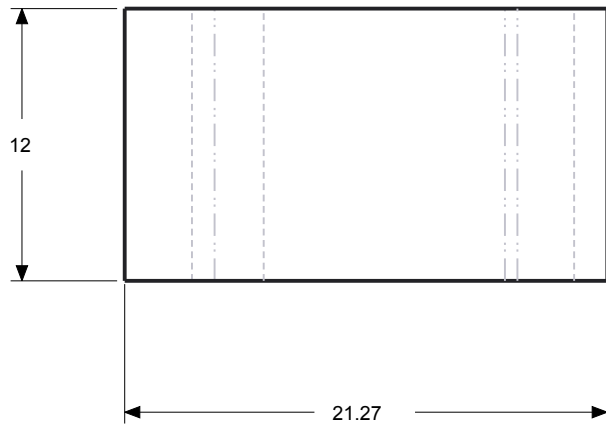
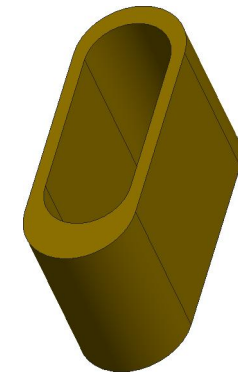
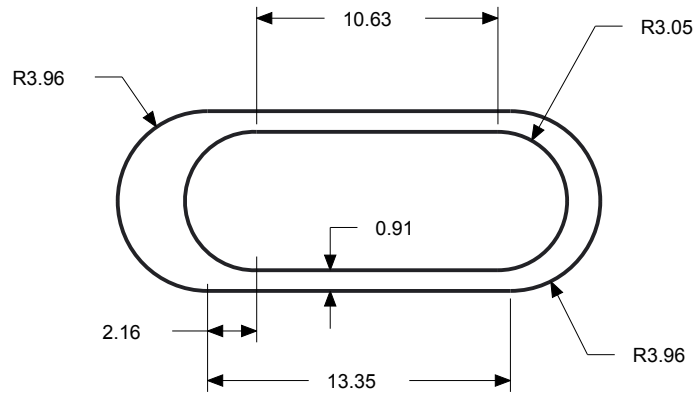
SCALE 0.750



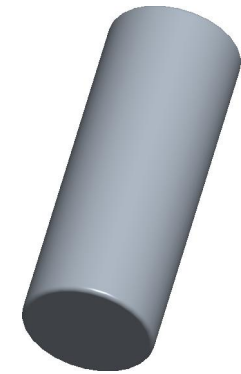
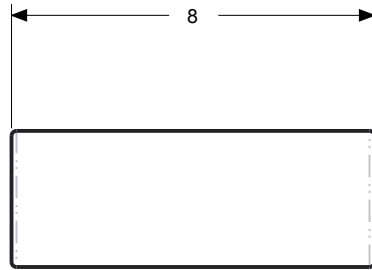
DETAIL A (SCALE 50.000)  
TRAILING EDGE

PROJECT STEPS 1-8		INLET GUIDE VANE MONITORING SYSTEM		
UNITS: MM		COMPANY SPONSOR	DEPARTMENT OF MECHANICAL ENGINEERING	SPONSOR
TOLERANCE	TOOL USED	DANFOSS TURBOCOR	FLORIDA STATE UNIVERSITY	WILLIAM BILBOW
(± 0.05)	CNC MILL	PROJECT COMPLETION	DRAWINGS REVIEWED	DESIGNER
PART NAME (NO. 2)	MATERIAL	MAY 4, 2018	FEBRUARY 28, 2018	PETER HOUSE
LEFT AIRFOIL	BRASS	SCALE (1.00)	SENIOR DESIGN TEAM 4	SHEET 6 OF 10



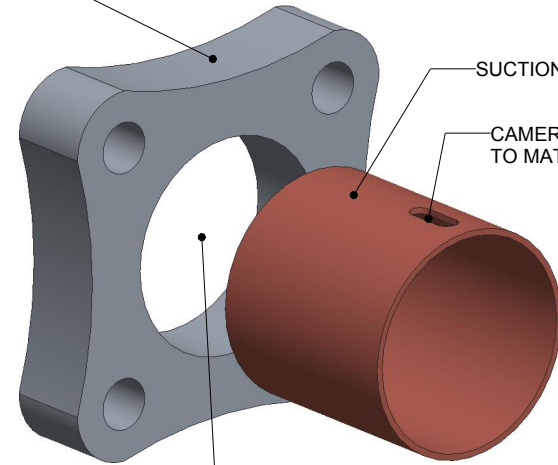


PROJECT STEP 3		INLET GUIDE VANE MONITORING SYSTEM		
	UNITS: MM	COMPANY SPONSOR	DEPARTMENT OF MECHANICAL ENGINEERING	SPONSOR
TOLERANCE	TOOL USED	DANFOSS TURBOCOR	FLORIDA STATE UNIVERSITY	WILLIAM BILBOW
(± 0.05)	CNC MILL	PROJECT COMPLETION	DRAWINGS REVIEWED	DESIGNER
PART NAME (NO. 6)	MATERIAL	MAY 4, 2018	FEBRUARY 28, 2018	PETER HOUSE
ENTRY PIECE	BRASS	SCALE (1.00)	SENIOR DESIGN TEAM 4	SHEET 7 OF 10



PROJECT STEP 5		INLET GUIDE VANE MONITORING SYSTEM		
	UNITS: MM	COMPANY SPONSOR	DEPARTMENT OF MECHANICAL ENGINEERING	SPONSOR
TOLERANCE	TOOL USED	DANFOSS TURBOCOR	FLORIDA STATE UNIVERSITY	WILLIAM BILBOW
N/A	N/A	PROJECT COMPLETION	DRAWINGS REVIEWED	DESIGNER
PART NAME (NO. 3)	MATERIAL	MAY 4, 2018	FEBRUARY 28, 2018	PETER HOUSE
ALIGNMENT PIN	STEEL	SCALE (6.00)	SENIOR DESIGN TEAM 4	SHEET 8 OF 10

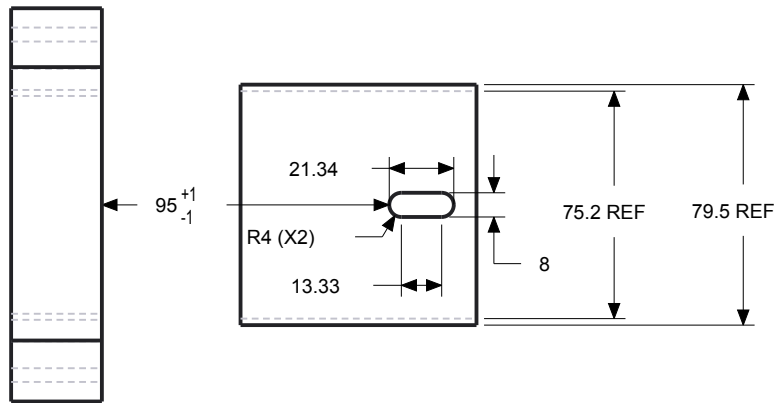
COMPRESSOR FLANGE CONNECTION  
(REPRESENTING THE SURFACE  
AS PART OF THE COMPRESSOR)



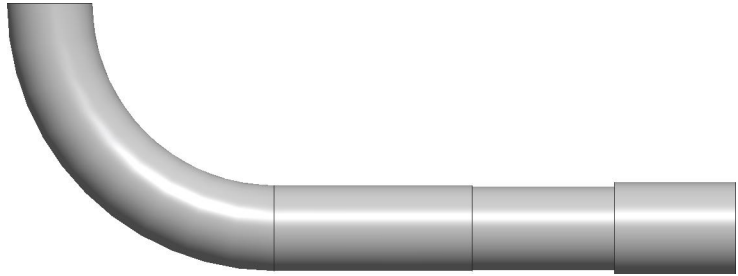
SUCTION PIPE

CAMERA ENTRY HOLE  
TO MATCH AIRFOIL

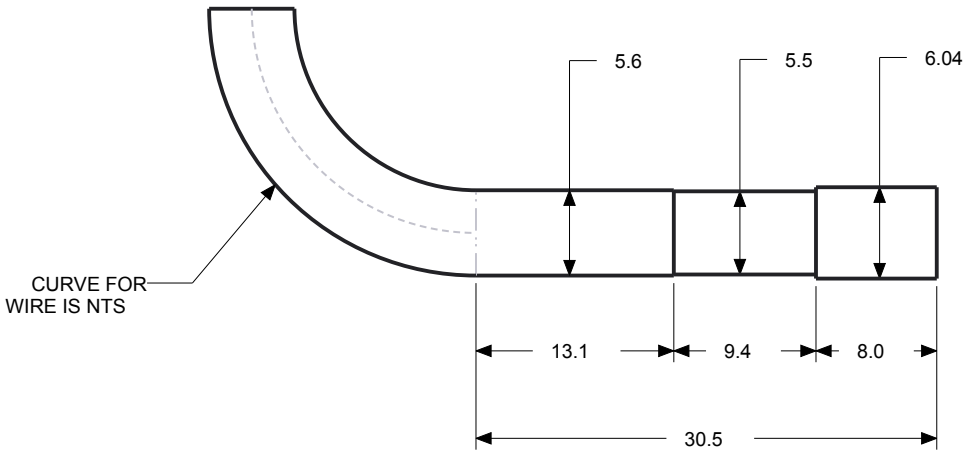
FLANGE CONNECTION  
NOT SHOWN  
DIMENSIONS ARE  
UNKNOWN



PROJECT STEP 9		INLET GUIDE VANE MONITORING SYSTEM		
UNITS: MM		COMPANY SPONSOR	DEPARTMENT OF MECHANICAL ENGINEERING	SPONSOR
TOLERANCE	TOOL USED	DANFOSS TURBOCOR	FLORIDA STATE UNIVERSITY	WILLIAM BILBOW
(± 0.05)	CNC MILL	PROJECT COMPLETION	DRAWINGS REVIEWED	DESIGNER
PART NAME (NO. 5)	MATERIAL	MAY 4, 2018	FEBRUARY 28, 2018	PETER HOUSE
SUCTION PIPE	COPPER	SCALE (0.400)	SENIOR DESIGN TEAM 4	SHEET 9 OF 10



HOUSING DIMENSIONS BASED ON VIDEOSCOPE HEAD LENGTH AND DIAMETER



VIDEOSCOPE HEAD REF		INLET GUIDE VANE MONITORING SYSTEM		
	UNITS: MM	COMPANY SPONSOR	DEPARTMENT OF MECHANICAL ENGINEERING	SPONSOR
TOLERANCE	TOOL USED	DANFOSS TURBOCOR	FLORIDA STATE UNIVERSITY	WILLIAM BILBOW
N/A	N/A	PROJECT COMPLETION	DRAWINGS REVIEWED	DESIGNER
PART NAME (NO. 6)	MATERIAL	MAY 4, 2018	FEBRUARY 28, 2018	PETER HOUSE
VIDEOSCOPE HEAD	MISC	SCALE (2.00)	SENIOR DESIGN TEAM 4	SHEET 10 OF 10