

IMAGES WP2.4

Modelling and Engineering large scale High
Temperature Thermal Energy Storage (HTTS)

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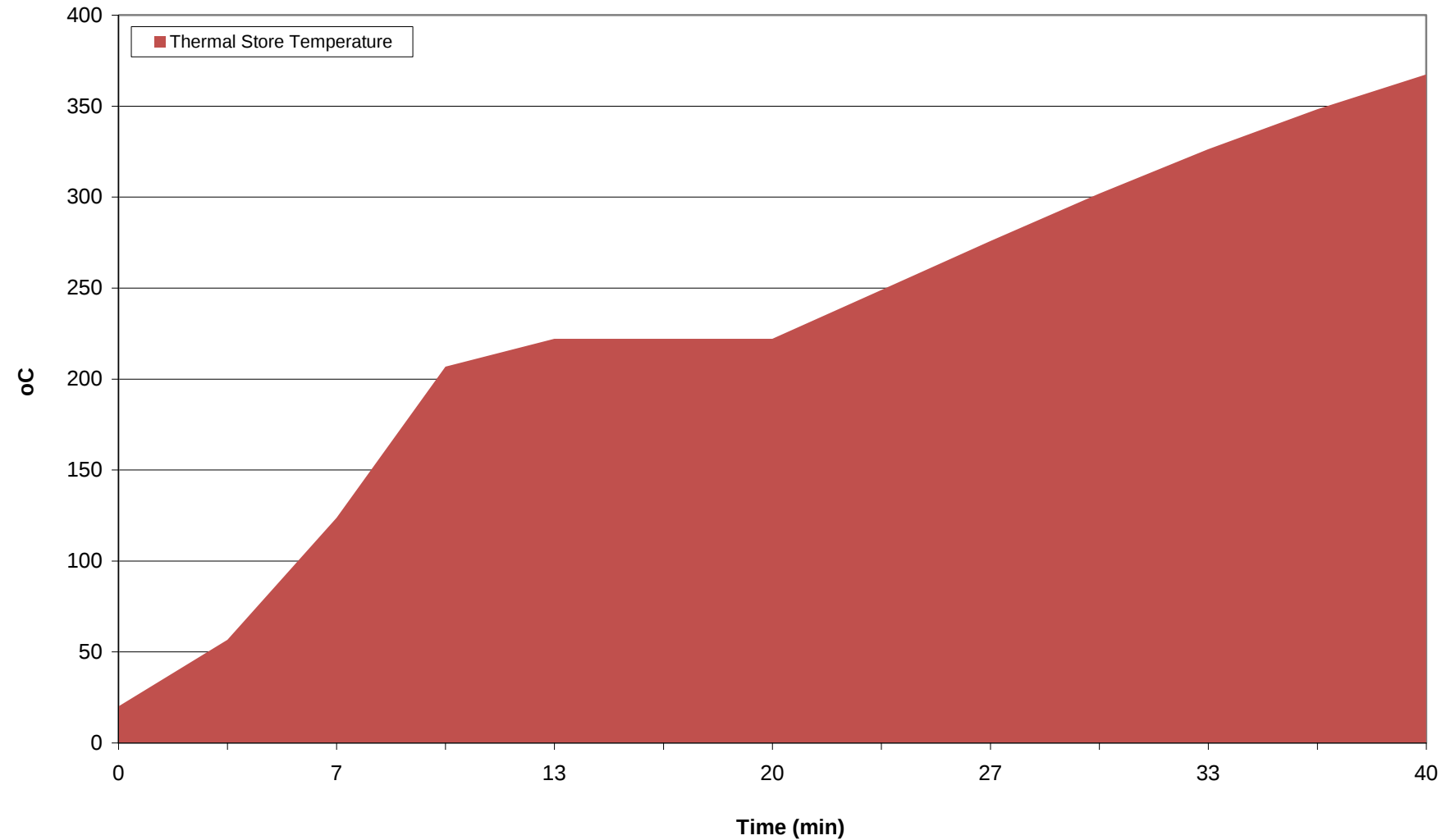
November 2016

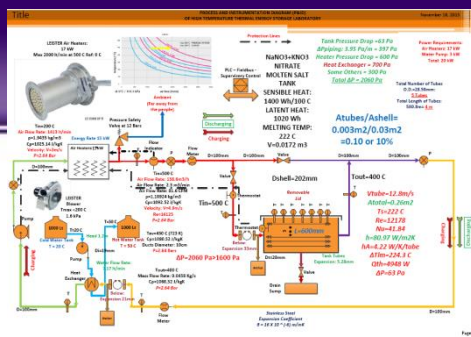


Laboratory Configuration Summary

	Tank (2.64 Bar)
Sensible Energy (Wh) /100 C	1400
Latent Heat (Wh)	1020
Volume (m3)	0.0172
Length (mm)	600
Diameter (mm)	202
Velocity in Tube (m/s)	12.8
Heat Transfer Area (m2)	0.26
Reynolds (Re)	12178
Nusselt (Nu)	41.84
Convection Heat Transfer Coefficient, h (W/m2k)	80.97
Thermal Energy Rate, Q (W)	4948
Number of Tubes	5
Ashell/Atubes (%)	90

THERMAL STORE TIME RESPONSE DURING CHARGING





Key System Components

1

Leister Air Heaters 17 kW



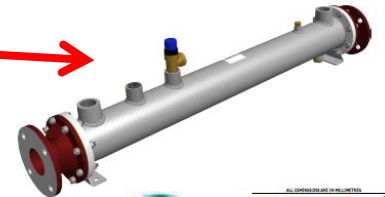
1

Leister Air Blower



1

Bowman Water/Air Heat Exchanger



1

WILO Water Pump
(Head 1.2 m / 7.17 lt/s)



2

1000 lt Water Tanks



1

Orifice Air Flow Meter, 600 C
/ 140 m3/h



Key System Components

A photograph of a pneumatic actuator assembly. It consists of a black solenoid valve at the top, connected to a black and orange pneumatic cylinder. The cylinder is connected to a metal valve body with a large circular flange at the bottom. A red arrow points to the bottom flange.

A green power cord is shown with a red arrow pointing to the ground pin (the longer, thinner pin) of the three-pronged plug.



	Components under Construction	
1	Pressure Safety Valve (5.4 Bar/ 600 C)	
1	Automation System	
1	Thermal Store	

ABB PLC500 Industrial Automation

Main Advantage: Real-time, on-line Control based on C/C++

4

A high performance PLC:

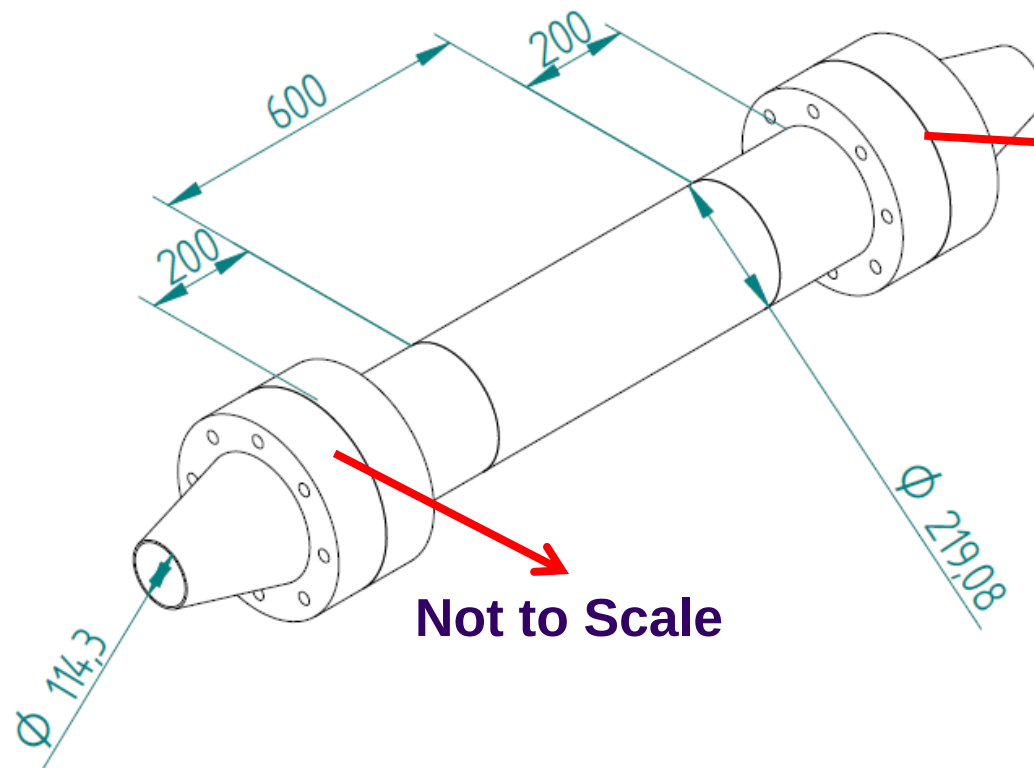
- Highly modular
- From 8 to +80 000 I/Os
- More communication possibilities (Ethernet, Internet, PROFINET®, PROFIBUS®, Modbus®, CANopen®, EtherCAT®...)

Common AC500 platform benefits: Automation Builder engineering suite, I/O modules, scalable and flexible



- Eight programming languages available (five IEC61131-3, CFC, C-code and C++)
- Data logging
- SD card for program back-up
- High Availability (HA) option
- Screw or spring terminal for I/Os
- Extensive programming libraries

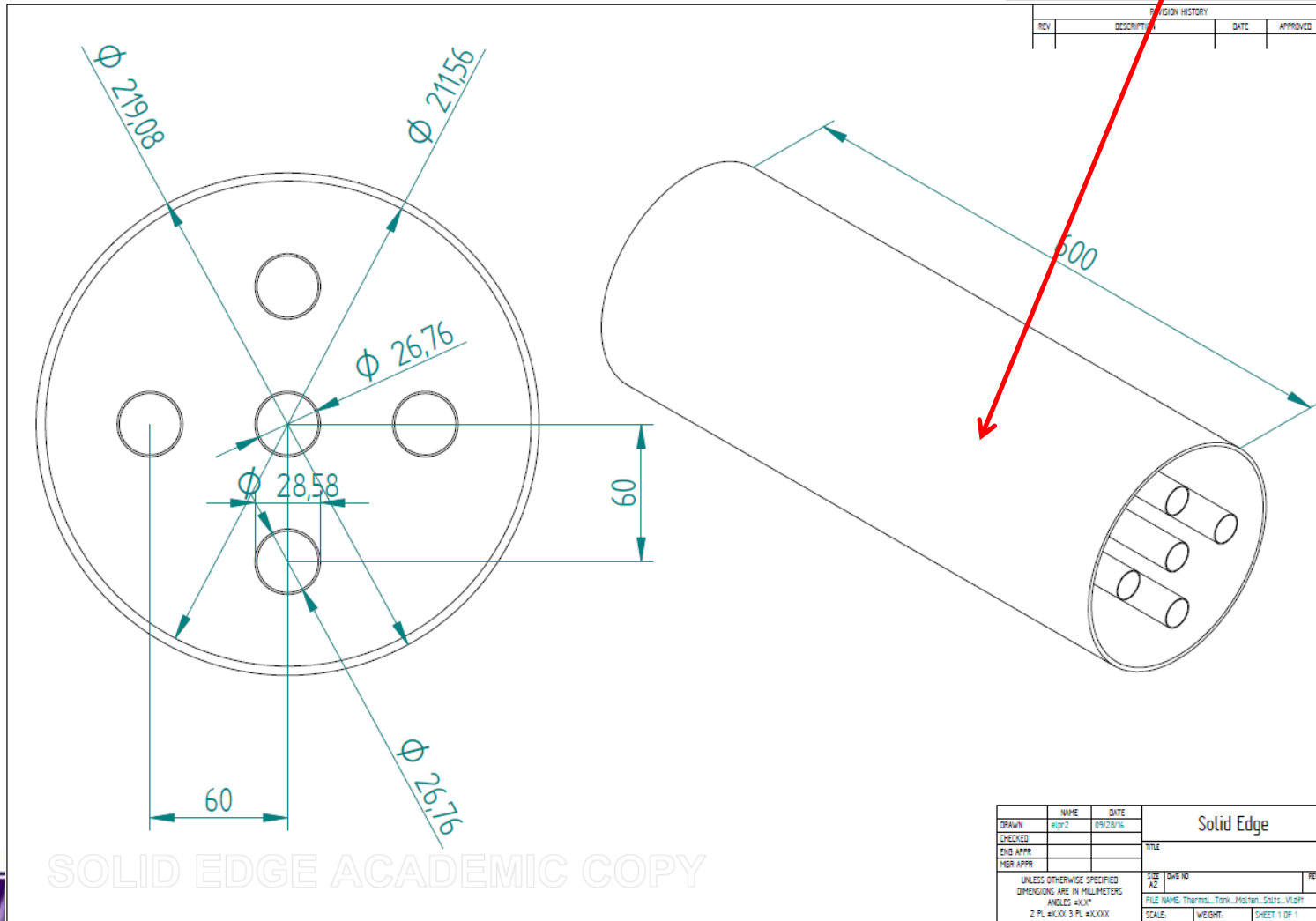
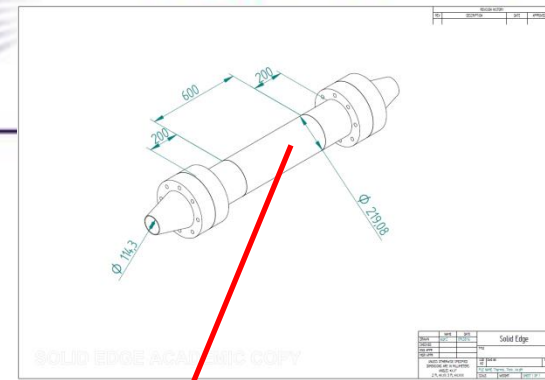
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REV	DESCRIPTION	DATE	APPROVED



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ENG APPR				
MGR APPR				
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS ANGLES *X.X*			SIZE A2	OWB NO
2 PL *X.XX 3 PL *X.XXX			FILE NAME: Thermal_Tank_V01.dft	
			SCALE:	WEIGHT:
			SHEET 1 OF 1	

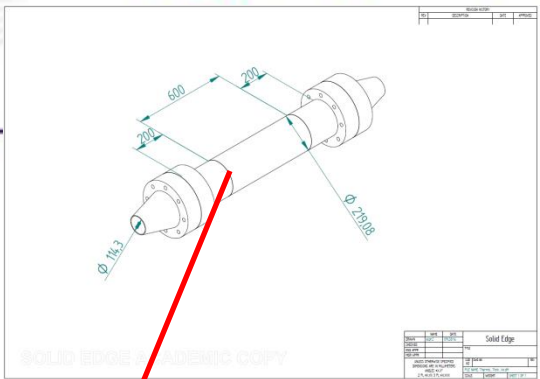
Thermal Store



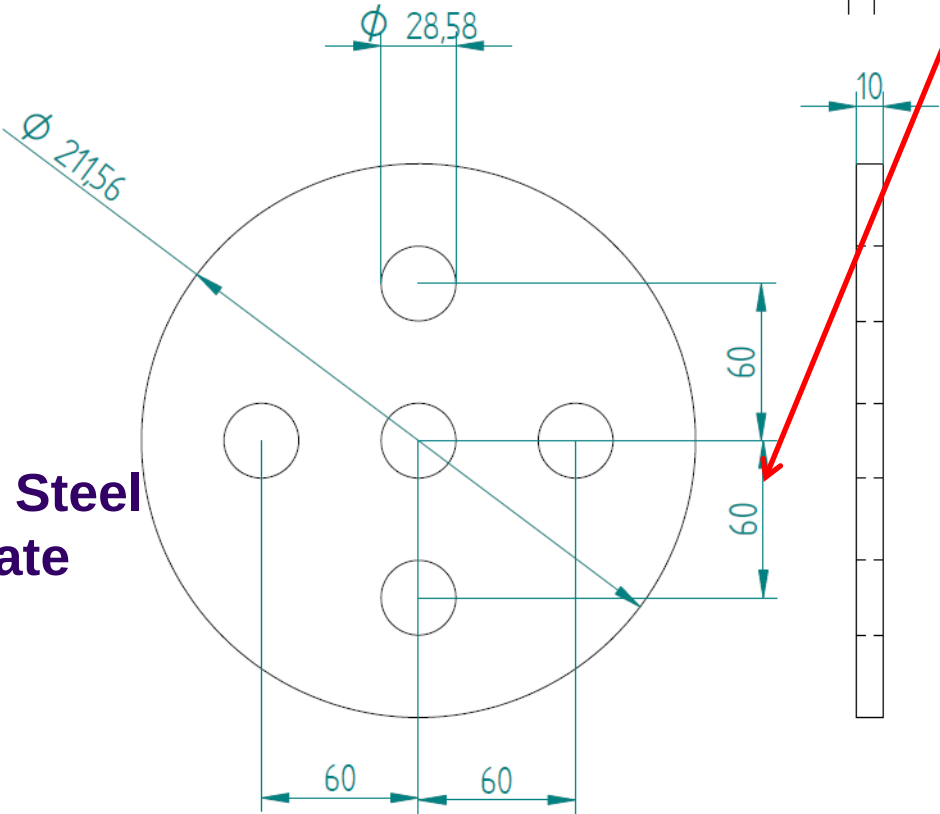
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2 PL. AXXX 3 PL. AXXXX				AZ	1
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					SHEET 1 OF 1

Tube sheets



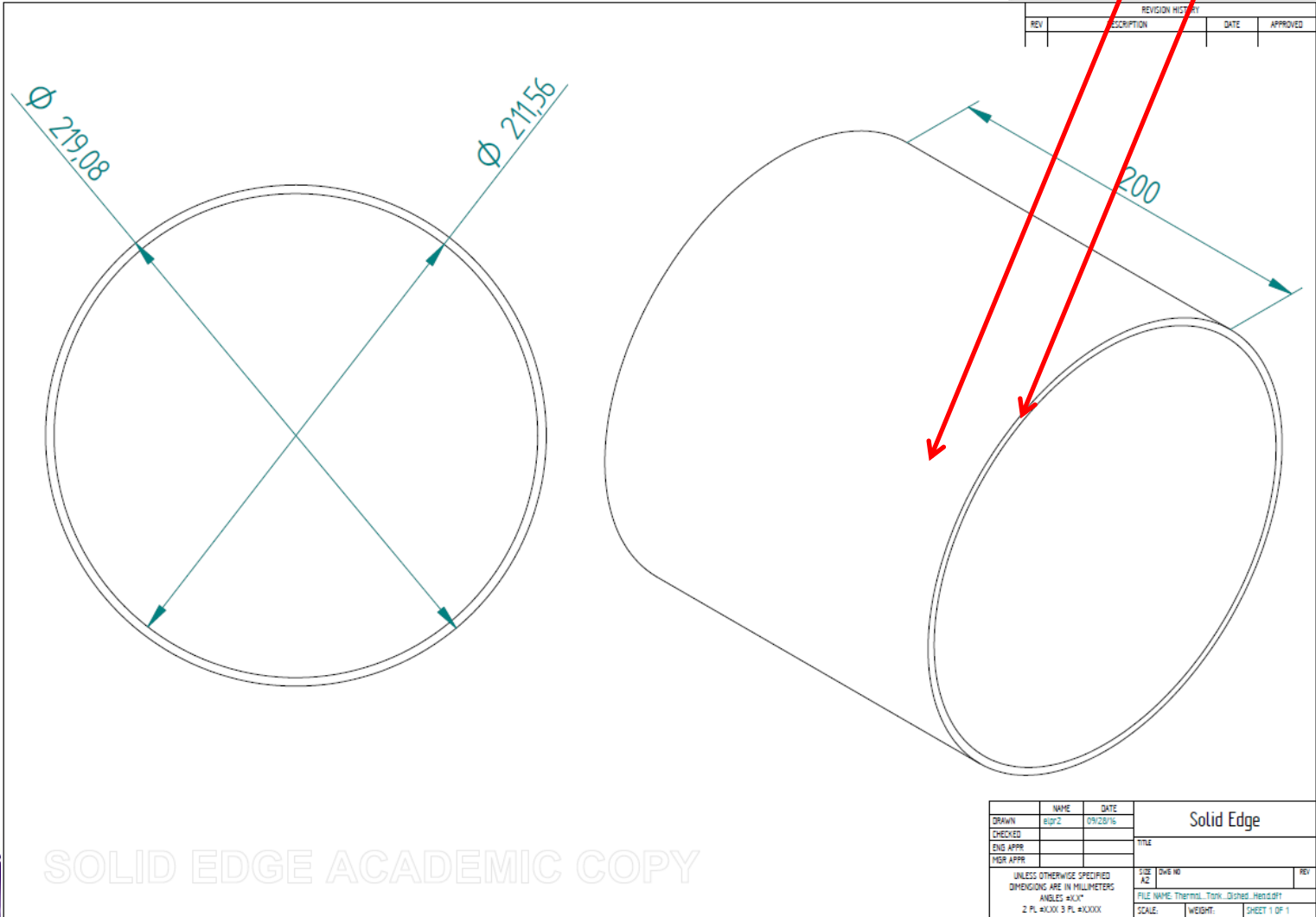
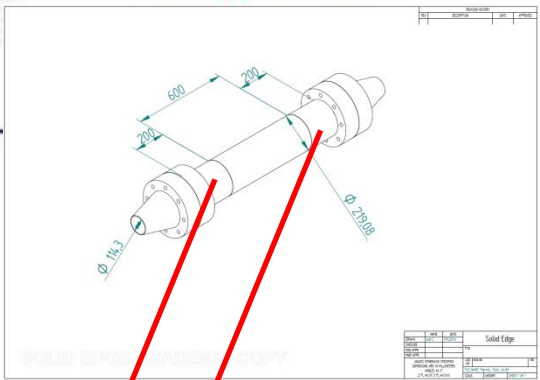
**Stainless Steel
316 Plate**



REVISION HISTORY			
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MECH APPR				SCALE: WEIGHT: SHEET 1 OF 1	
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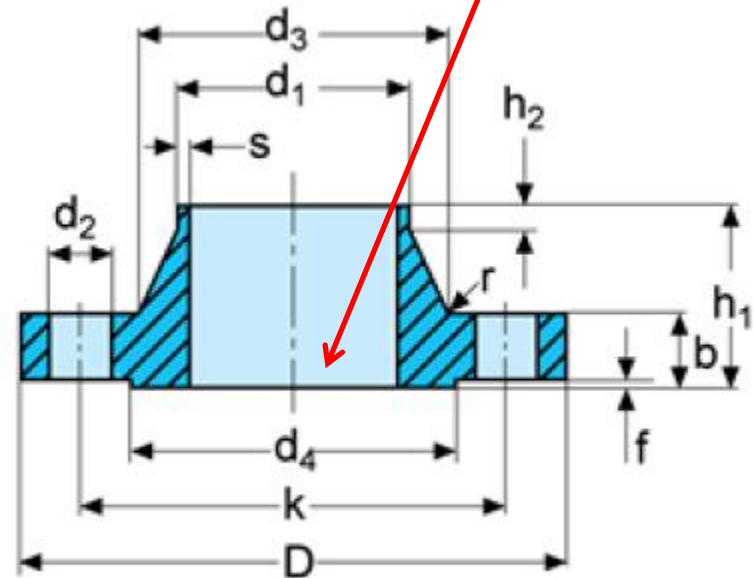
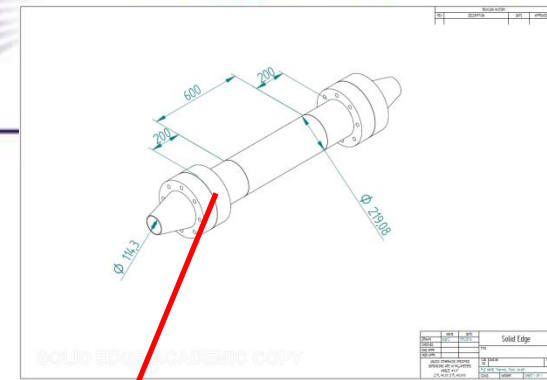
Heads Units



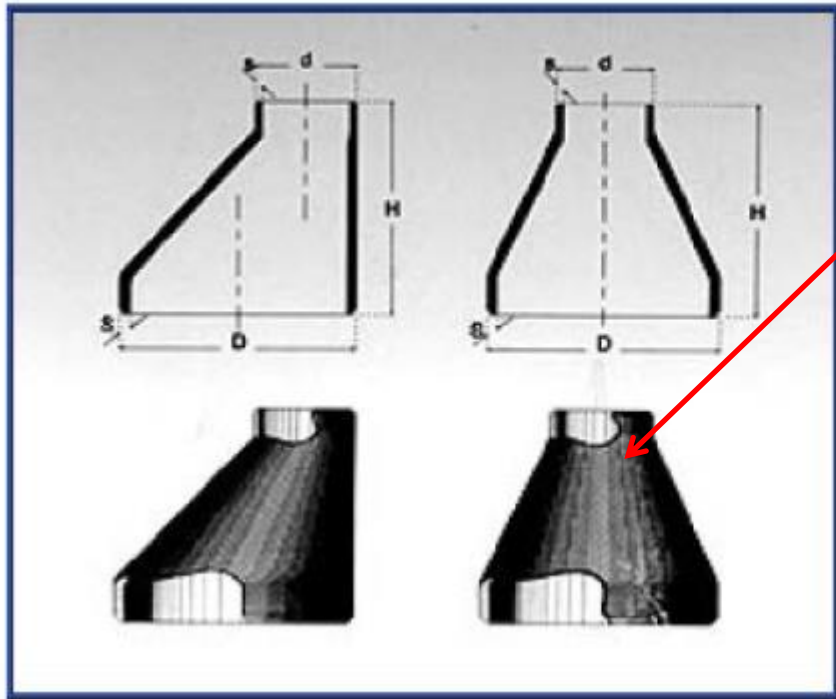
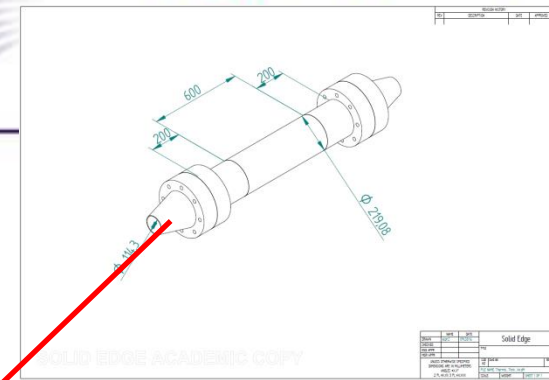
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ENG APPR	NAME	DATE
MECH APPR	NAME	DATE
Solid Edge		
TITLE		
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Welding Neck Flanges PN16



Concentric reducers STD



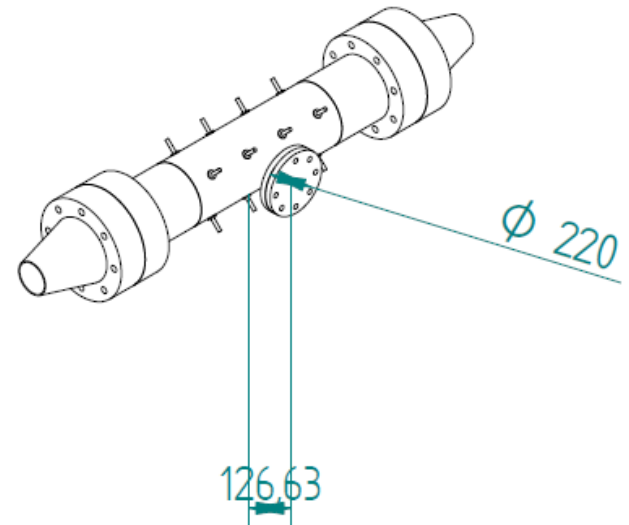
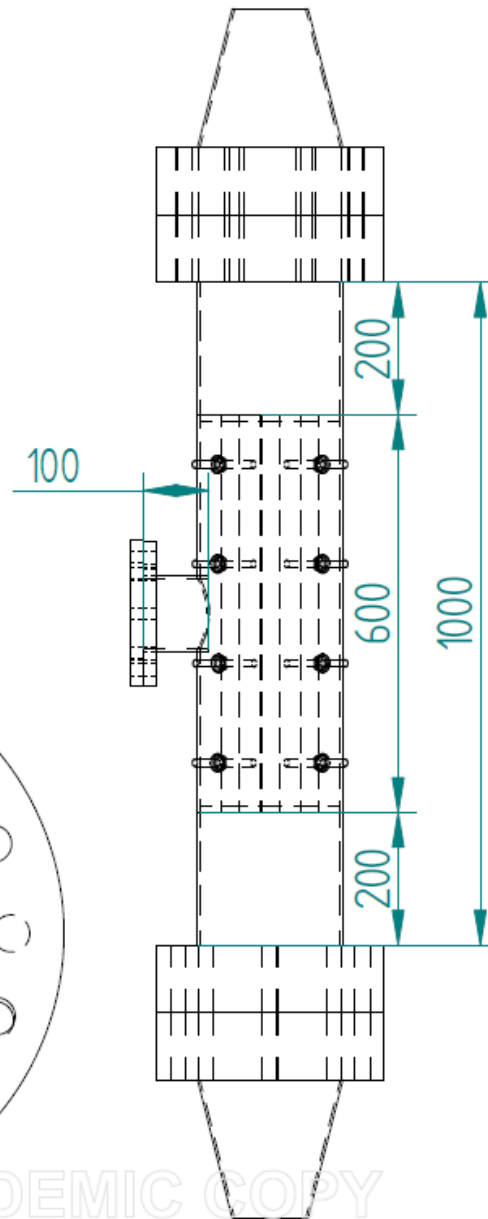
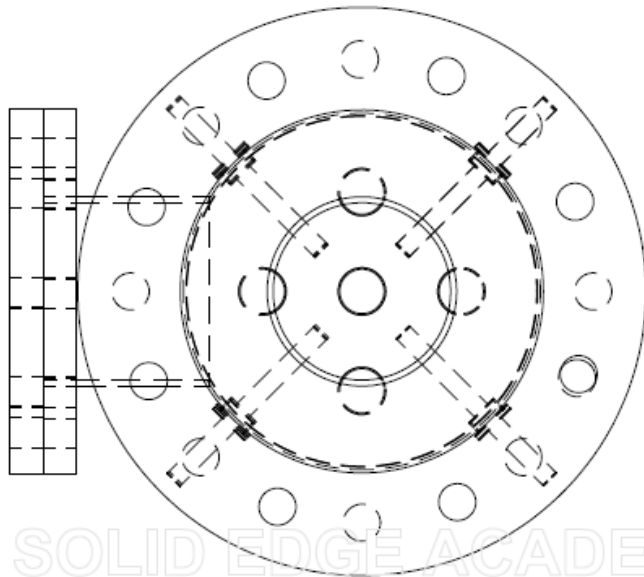
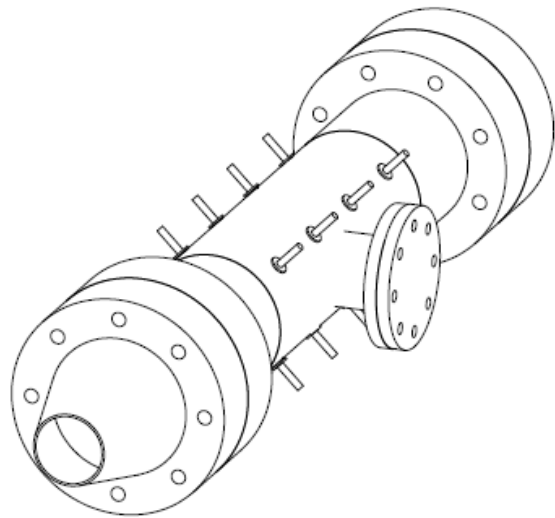
Concentric and eccentric reducers STD

Norm: ANSI B 16,9
Steel: carbon steel ASTM A234 WPB
Thickness: STD
Certification: 3.1.B



Scale:			Material:			Remove All Burrs and Sharp Edges.		Finish:	
Issue	Date	Issue	Date	Issue	Date	Tolerances Unless Otherwise Stated Full Millimetres ± .5 mm One Decimal Place ± .15 mm Two Decimal Places ± .025 mm	Drawn L. Blount		
	Drawn		Drawn		Date August 1988				
	Approved		Approved		App'd				
						Customer	Date	Standard Fabricated Resistance Thermometer or Thermocouple Assy	
						Order No.	Certified		
						Date			
						Drp. No. CDL 1024			Shl of

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED



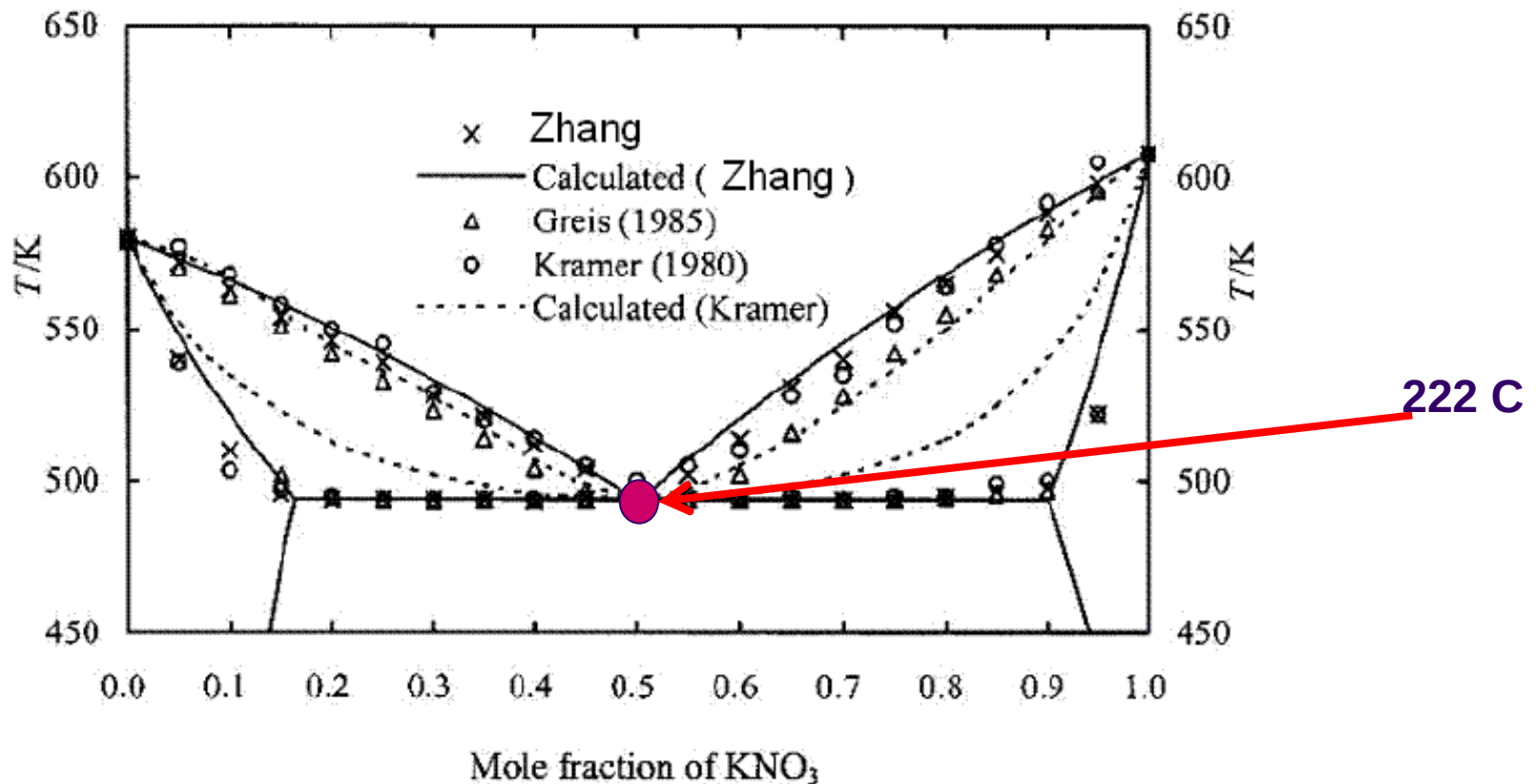
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MGR APPR			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS ANGLES IN DEGREES		SIZE A2	QWS NO
2 PL 4000 3 PL 4000X		FILE NAME: Thermol_Task_VT0162.DPT	REV
		SCALE	WEIGHT
		SHEET 1 OF 1	

SOLID EDGE ACADEMIC COPY

Properties of Potassium and Sodium Nitrate (KNO₃+NaNO₃)

- ***NaNO₃/KNO₃ (46:54)***
- **Fusion Enthalpy:** 108 kJ/kg
- **Density:** 1.959 kg/m³
- ***Energy Density:*** 30 MWh/tonne or 30 MWh/510 m³
- **Melting Temperature:** 222 C

Overview of different phase diagrams of the system $\text{KNO}_3 - \text{NaNO}_3$



Thomas Bauer, Doerte Laing and Rainer Tamme. Overview of PCMs for concentrated solar power in the temperature range 200 to 350 °C. doi:10.4028/www.scientific.net/AST.74.272.

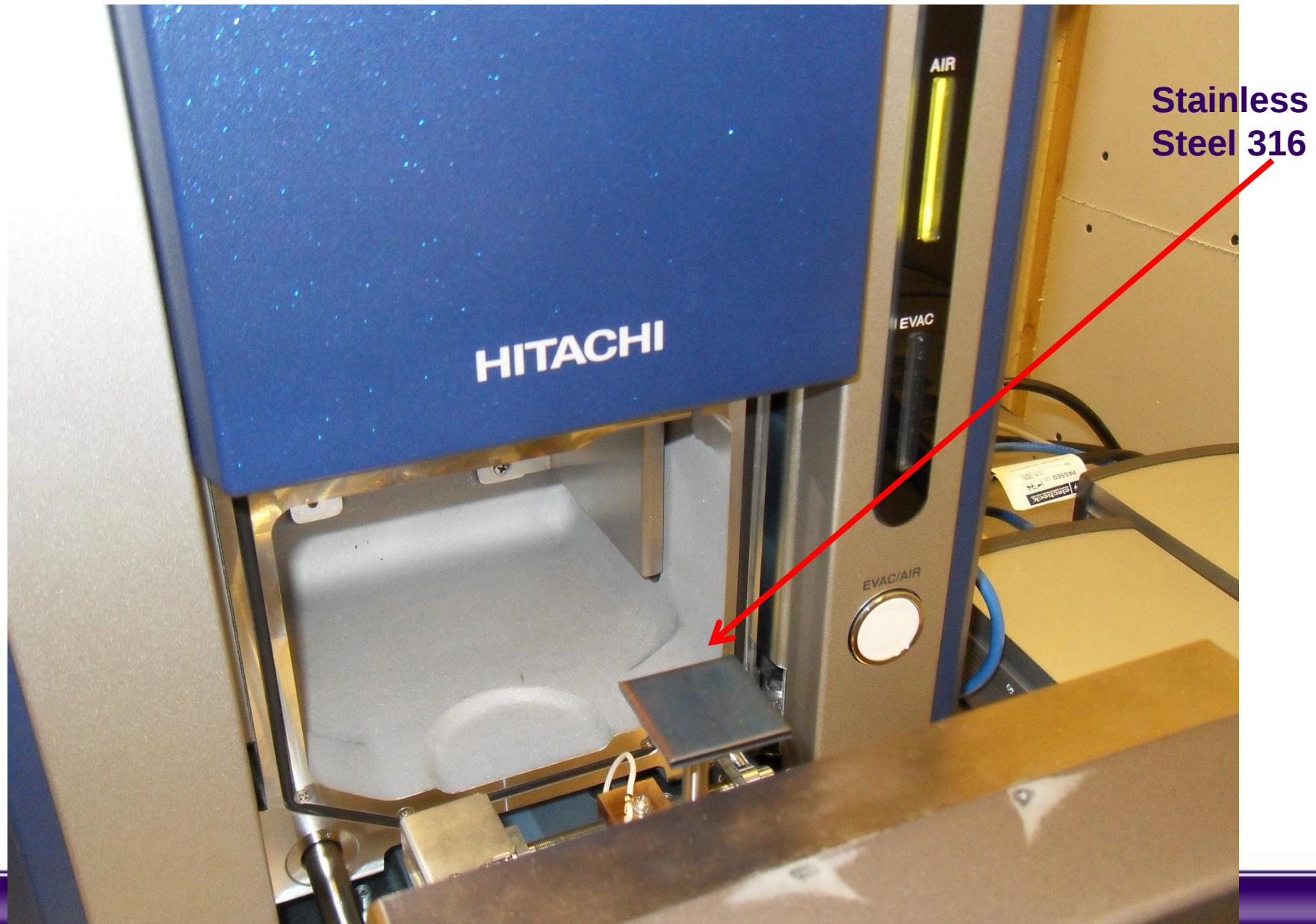
Corrosion Test at 400 C for the Mixture $\text{NaNO}_3\text{-KNO}_3$ (46%-54%)



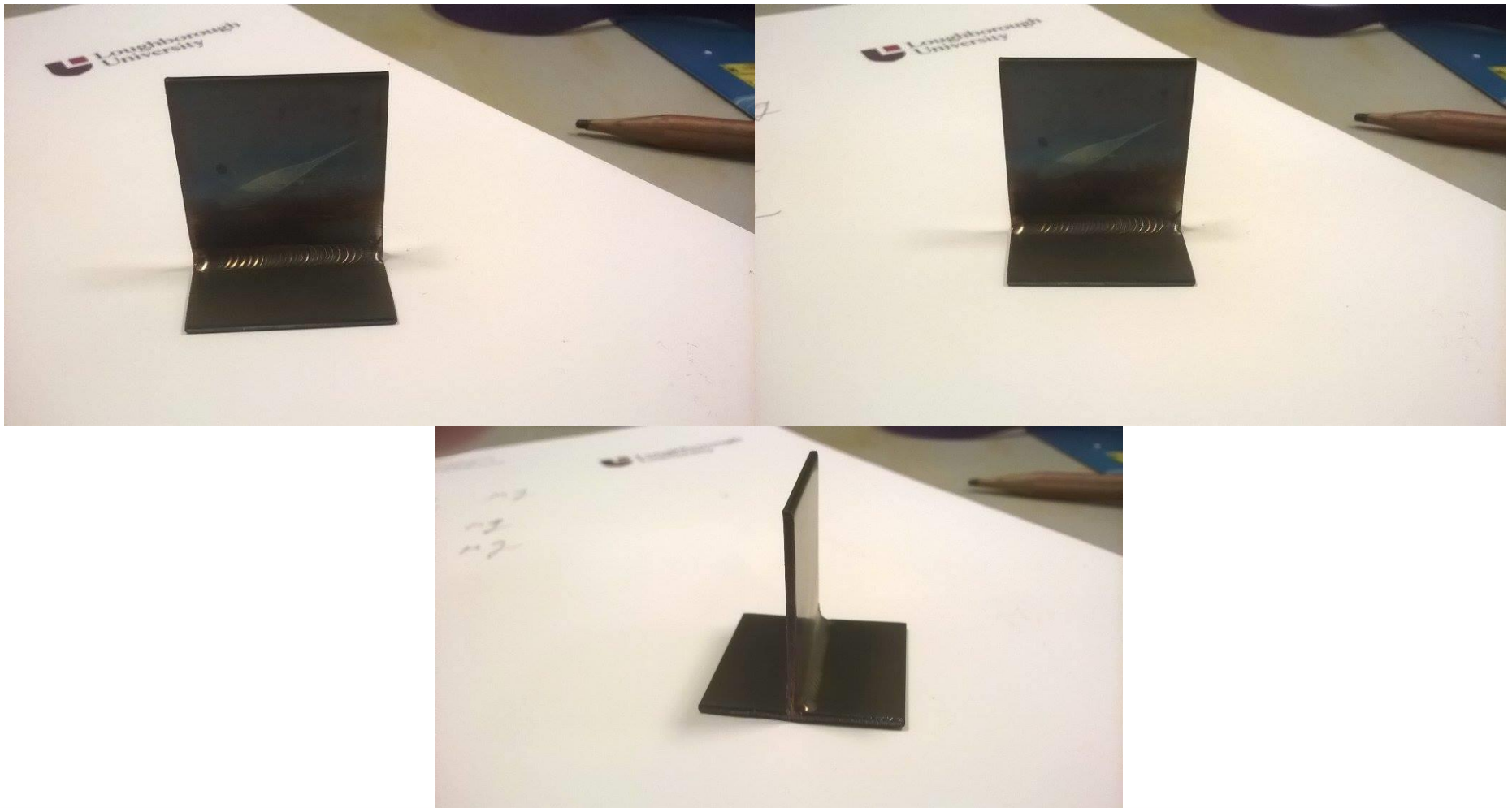
Initial Corrosion Tests on SS 316 performed at 400 C using Mixture NaNO₃-KNO₃ (46%-54%) for 1 Month



Sample being mounted in a bench top SEM

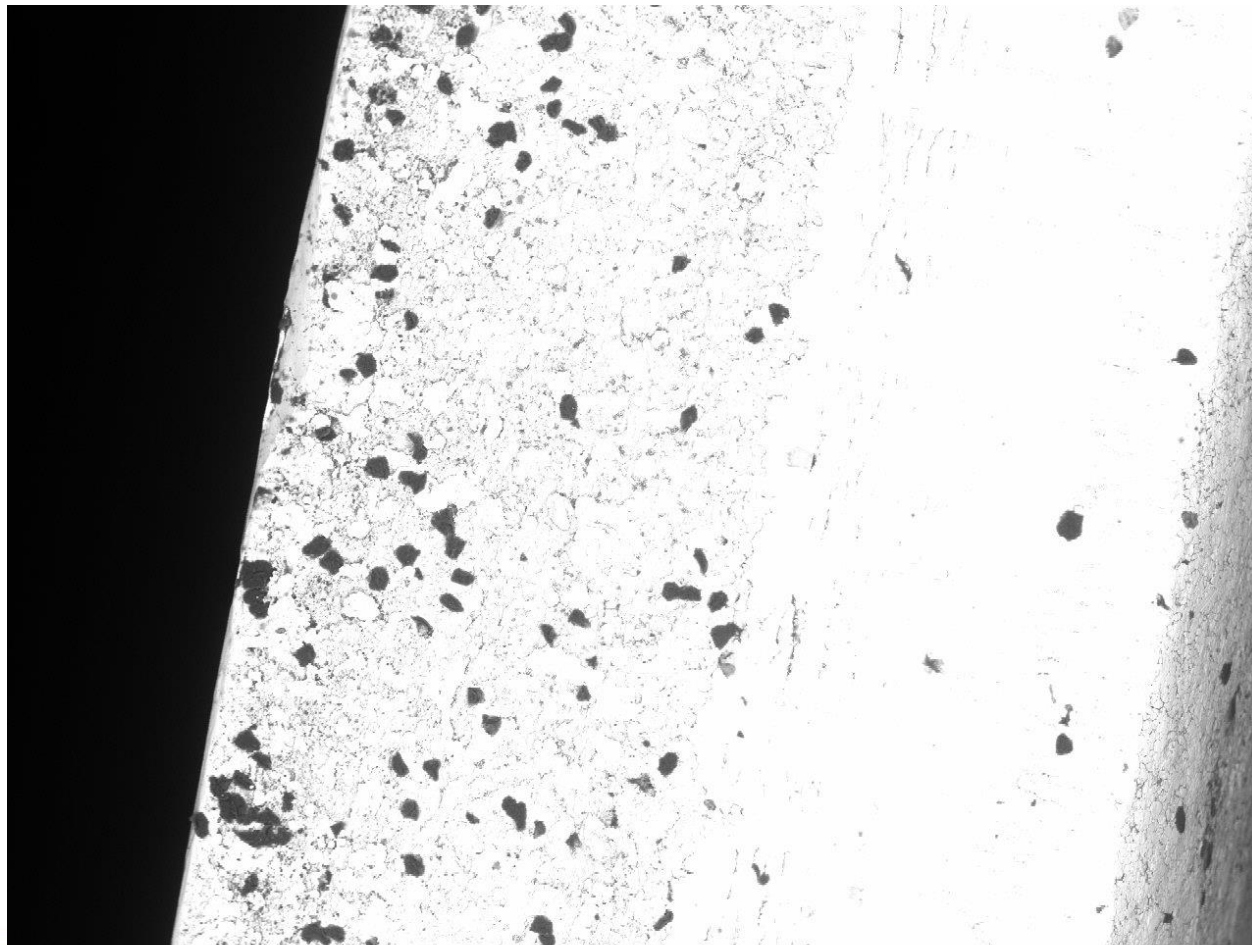


Welded Samples Produced for Corrosion Test at 400 C with the Mixture $\text{NaNO}_3\text{-KNO}_3$ (46%-54%)



SEM Image of Welding Corrosion Test at 400 C for the Mixture NaNO₃-KNO₃ (46%-54%)

- Weight change in 7 days, $\Delta W = 0.1$ mg from 21358.3 to 21360.8 mg



Wax F0007

AL D4.6 x100 1 mm

Conclusions

- A first prototype system has been designed and is being constructed for testing at CREST
- Final Components are being manufactured
- Corrosion Tests of both stainless steel 316 sample and welded joints stainless steel samples have been performed
- Simulations are being developed for the different storage approaches

***Thank you for your
Attention!***

P. Romanos