



High Temperature System Designs, LLC

High Temperature Molten Salt R&D Loops For MSR Applications

**R&D Test Loops are Critical in the
Development of New MSR Technologies**

**R&D Validation of Materials, Pumps, Reactors, Valves,
Piping, Monitoring Devices and System Modes of
Operation will De-Risk the Technology and make it
Bankable.**



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R&D Test Loops are Custom Designed and can be very small desktop systems, small laboratory systems to pilot plant scale systems.

When designing a Custom R&D Test Loop it is critical to define the lessons to be learned and the Risks to be mitigated.

Drawing from the Experience of our National Labs, Universities and Private Sector Companies specializing in designing systems will eliminate the pitfalls in molten salt test systems.



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Safety is Your # 1 Concern

The 4 Major Problems with Molten Salt Systems

- 1. Freeze ups within the system**
- 2. Leaks within the system**
- 3. Working environments**
- 4. Human errors in designing the system**

Anyone of these or combination of the four can result in the loss of life or severe burns to your employees and catastrophic damage to the your facility!!!

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Be sure to wear the proper **Personal Protection Equipment** and use the proper tools when working with molten salt test.





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What are the features of a well designed test loop

- 1. Your loop should be self-draining to a main reservoir**
- 2. Your loop could have options for forced flow or natural circulation**
- 3. Your loop should be capable to be expanded**
- 4. Your loop should have multiple heating & cooling options**
- 5. Your loop could have multiple test sections within the loop**
- 6. Your loop should have zoned temperature controls & monitoring to prevent Freeze Ups ~ Do not forget your transfer lines**
- 7. Your loop should have options for additional tanks such as a purification and storage**



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Features of a well designed test loop ~ continued

- 8. Your loop should minimize leak points such as flanges, valves, and sensors**

- 9. Your loop should have well defined modes of operation and shut down procedures**

- 10. Your loop should have work platforms and supporting frame**

- 11. Your support structure needs freedom of movement from thermal expansion**

- 12. The loop should have an adequate power supply for pump, heaters, heat tracing**

- 13. The Safety Zones should be well defined to prevent personnel from being near the loop when operating with molten salt.**



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Most Critical Components within the Loop!!

- 1. Your Pump ~ It is the Heart of your system, if it does not work properly your entire system could be down!!**
- 2. Your Tanks ~ If they leak, you have a major mess and your down!!**
- 3. Your Valves ~ If they freeze up and leak, your down!!**
- 4. Your Thermal Monitoring system ~ It tells you the condition of your entire system and where problems are starting to occur!!**
- 5. Your Heaters ~ Melting of the salt, preheating the system and controlling the temperature of the salt during testing is critical**



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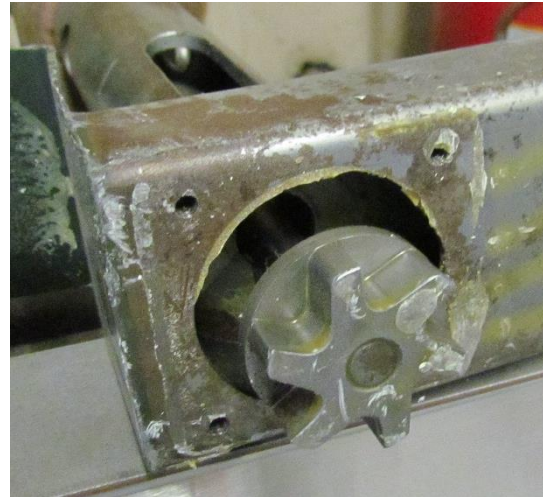
Test Loop come in many different Sizes and Designs

Bench Top Loops (1/4”-1/2” Piping) require very small Custom manufactured components and are generally very simple in design testing one or two aspect of a commercial system.

Laboratory size Loops (1”-2” Piping) require small commercially available components and can have multiple test areas within the loop. Many features start to become scalable for pilot systems and even commercial plants.

Pilot size Loops (3”-6” Piping) require medium size commercially available component and can be very complex, testing multiple features of a commercial system. Validation to De-Risk critical components for commercial size systems is a major goal of this size loop.

Bench Top Loops will require Miniature Pumps and Tanks



Small alloy investment casings are used on miniature vertical cantilever designs for High Temperature Molten Salts up to 850 deg. C





University and Laboratory Molten Salt Test Loops all start with the Pump

The Heart of the system is the pump and molten salt tank/heater assembly. If you need a Purification/Storage Tank system, then we add it upstream of the pump.

The entire system need to be able to be drained back into the pump reservoir when the system is not in operation or you have an upset emergency condition occur.



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Custom built systems can include the pump, motor, VFD, tank, heaters and controllers

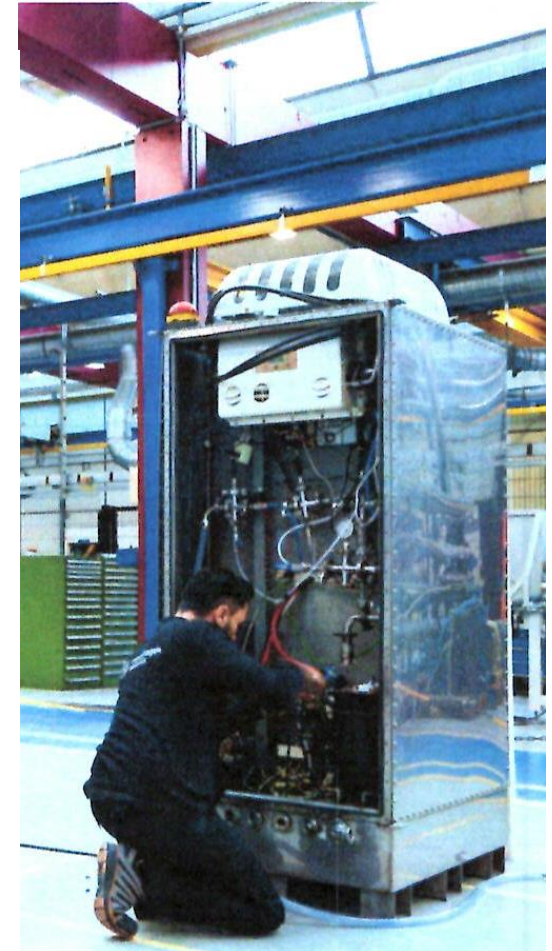
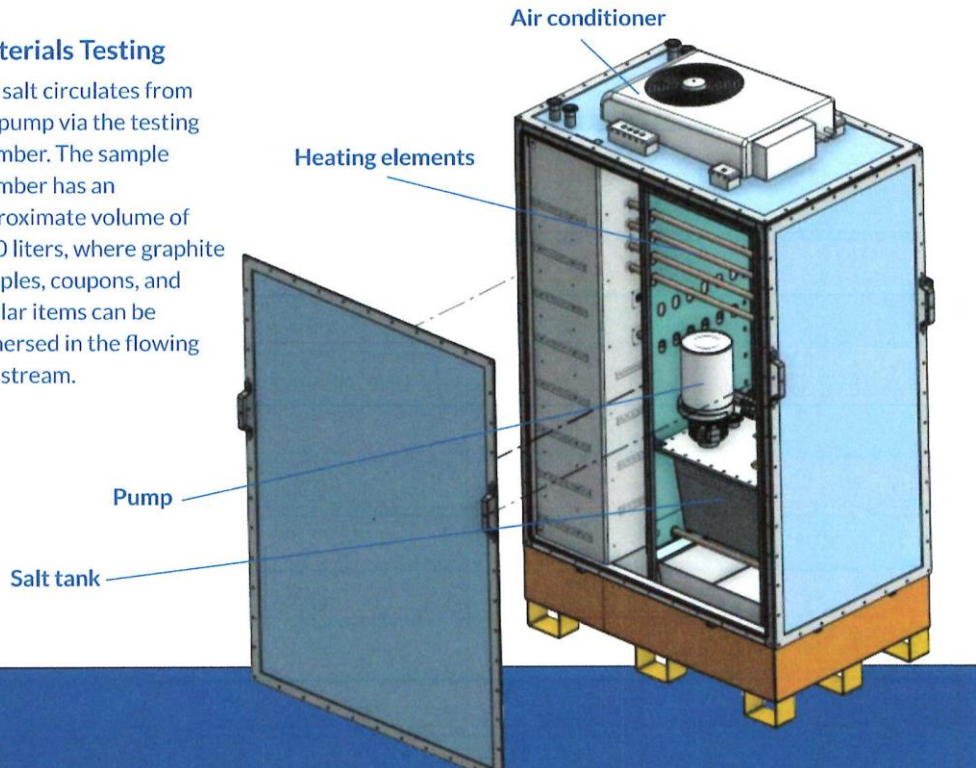


Complete modular pumping systems can be incorporated into laboratory test loops



Materials Testing

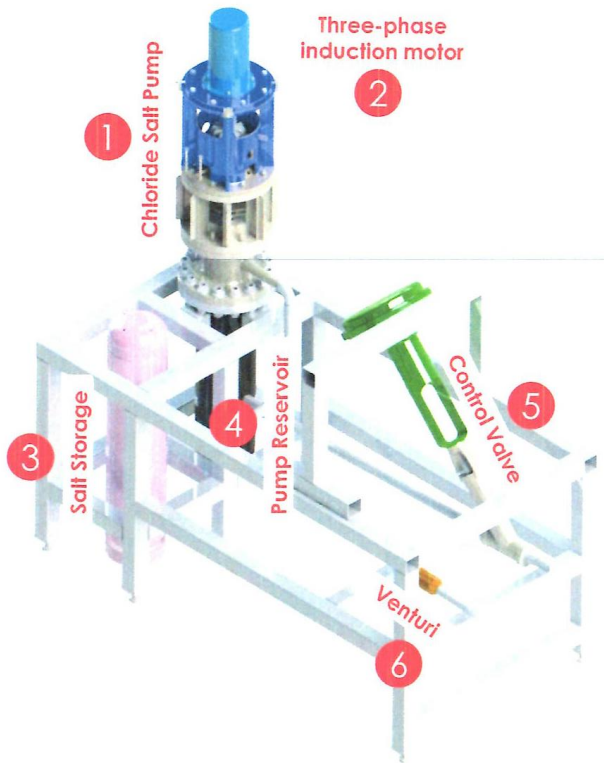
The salt circulates from the pump via the testing chamber. The sample chamber has an approximate volume of 5-10 liters, where graphite samples, coupons, and similar items can be immersed in the flowing salt stream.



University of Madison Wisconsin

UMW has built many specialized test loops and test rig

Testing with Molten Chloride salts at 720 deg. C



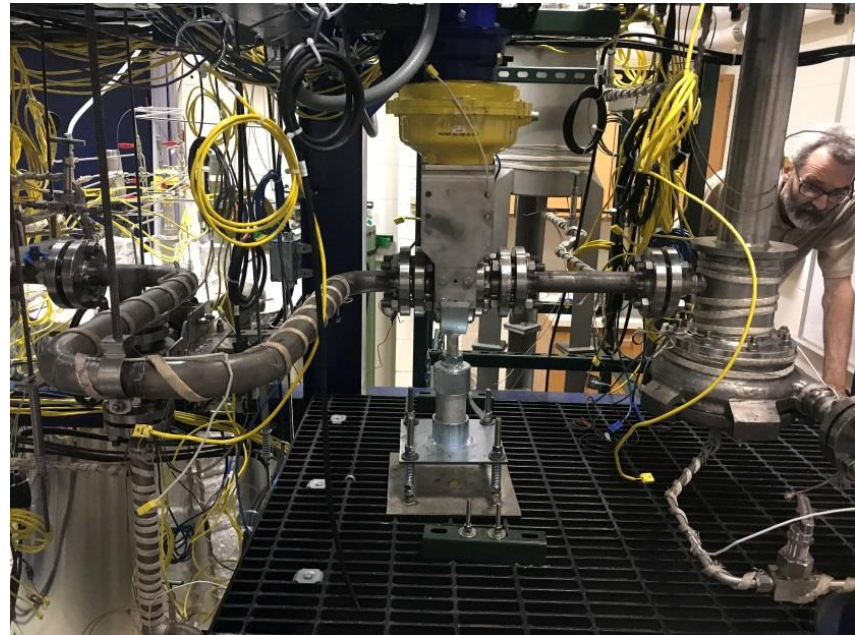
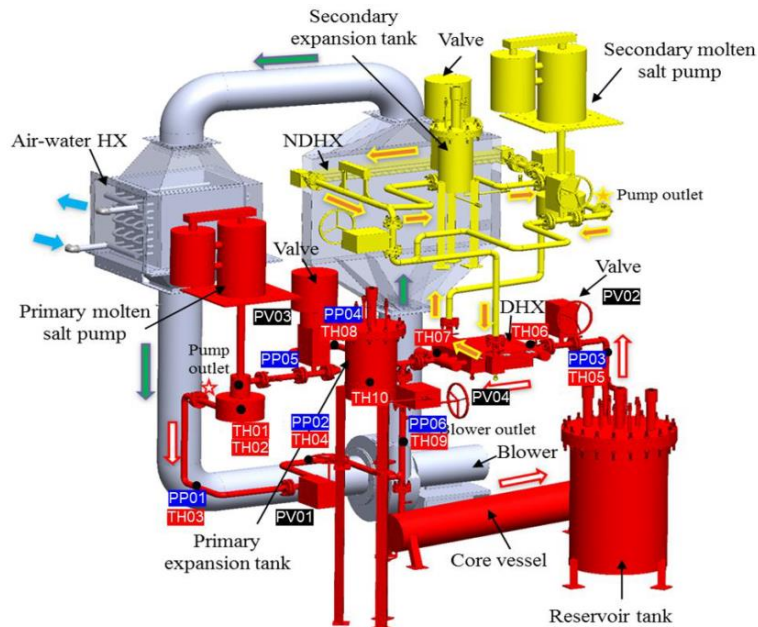
Photos courtesy of UMW and Sulzer pump

University of Michigan Test Loop

UM has one of the most complex molten salt loops using both Hot and Cold salt loops

High-Temperature FLUoride Salt Test Facility (FLUSTA)

- ❑ Design specifications: power scale ratio 1/1250, length scale ratio 1/10
- ❑ Three loops: two salt loops and one air loop
- ❑ Salts: FLiNaK (650 ~ 700 °C), FLiNaK(550 ~ 600 °C)
- ❑ Two Nagle vertical cantilever pumps (~0.12 kg/s salt flow)
- ❑ 1.25" SS 316 piping; plan to commission in 2020

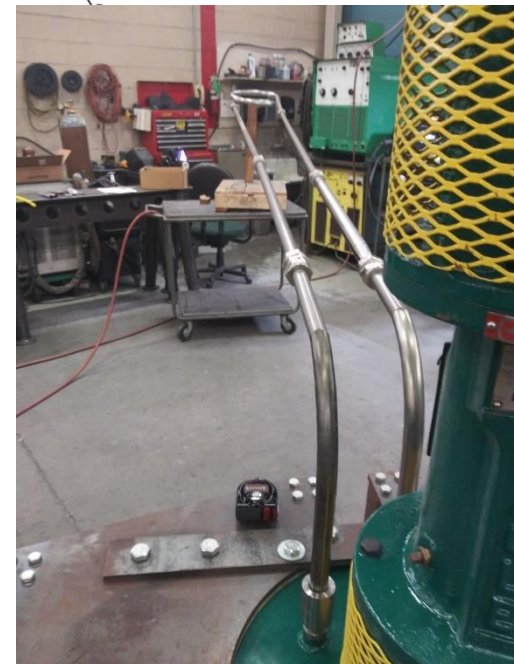
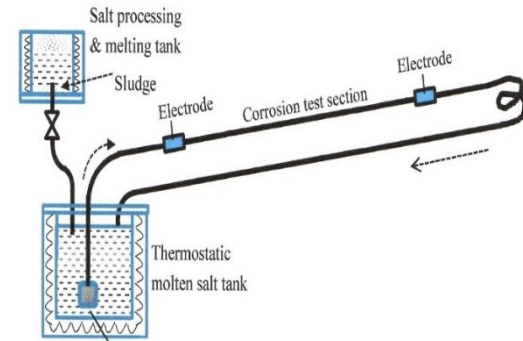


Photos courtesy of UM

University of Arizona Test Loop

UA has built multiple test loops to study different salts blends and monitoring sensor

- Nagle Pump is Inconel 600. Flow 10 gpm TDH 20 ft
- Tanks Hastelloy C276 Capacity 30 Gallons
- Molten Chloride salt at 750 C
- Component testing of sensors, valves, flowmeters
- Ready to start when university re-opens



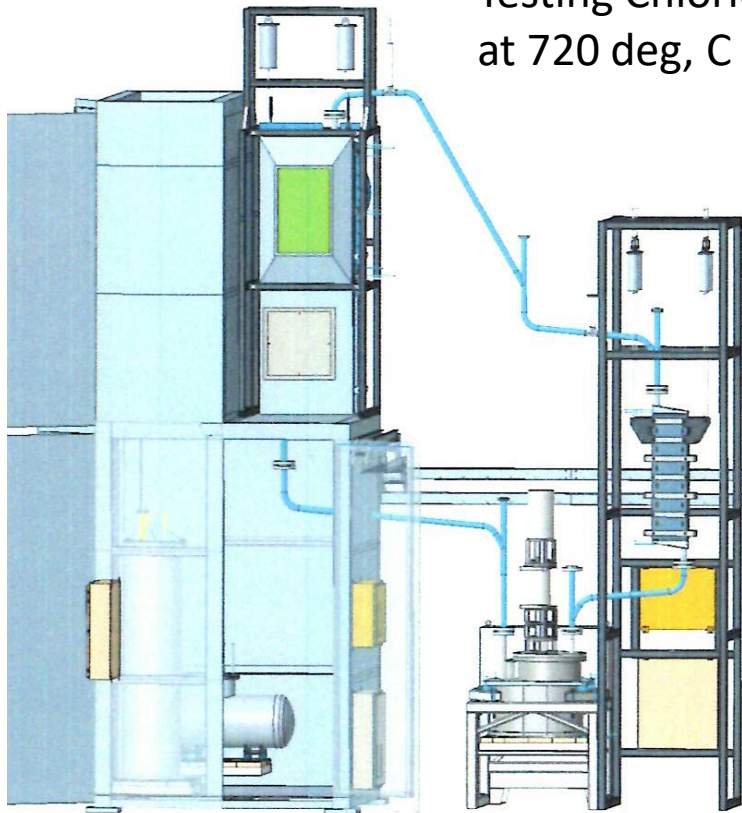
Test Loops can be Very Large



**Sandia's Molten Salt Test Loop (MSTL)
MSTL is currently waiting for a restart of the loop**

ORNL FASTR LOOP Currently being commissioned at ORNL

Testing Chloride Salts
at 720 deg, C





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Molten Salt Test Loops no matter what the size (Bench, Laboratory or Pilot Scale) all start with a conceptual idea of what is to be tested and the lessons to be learned.

The lessons learned at our National Labs and Universities will help the private developers of MRS designs, build test loops to De-Risk their technologies.

Teaming with private sector engineering/design companies and using proven equipment suppliers will ensure a trouble free start up of your molten salt test loop



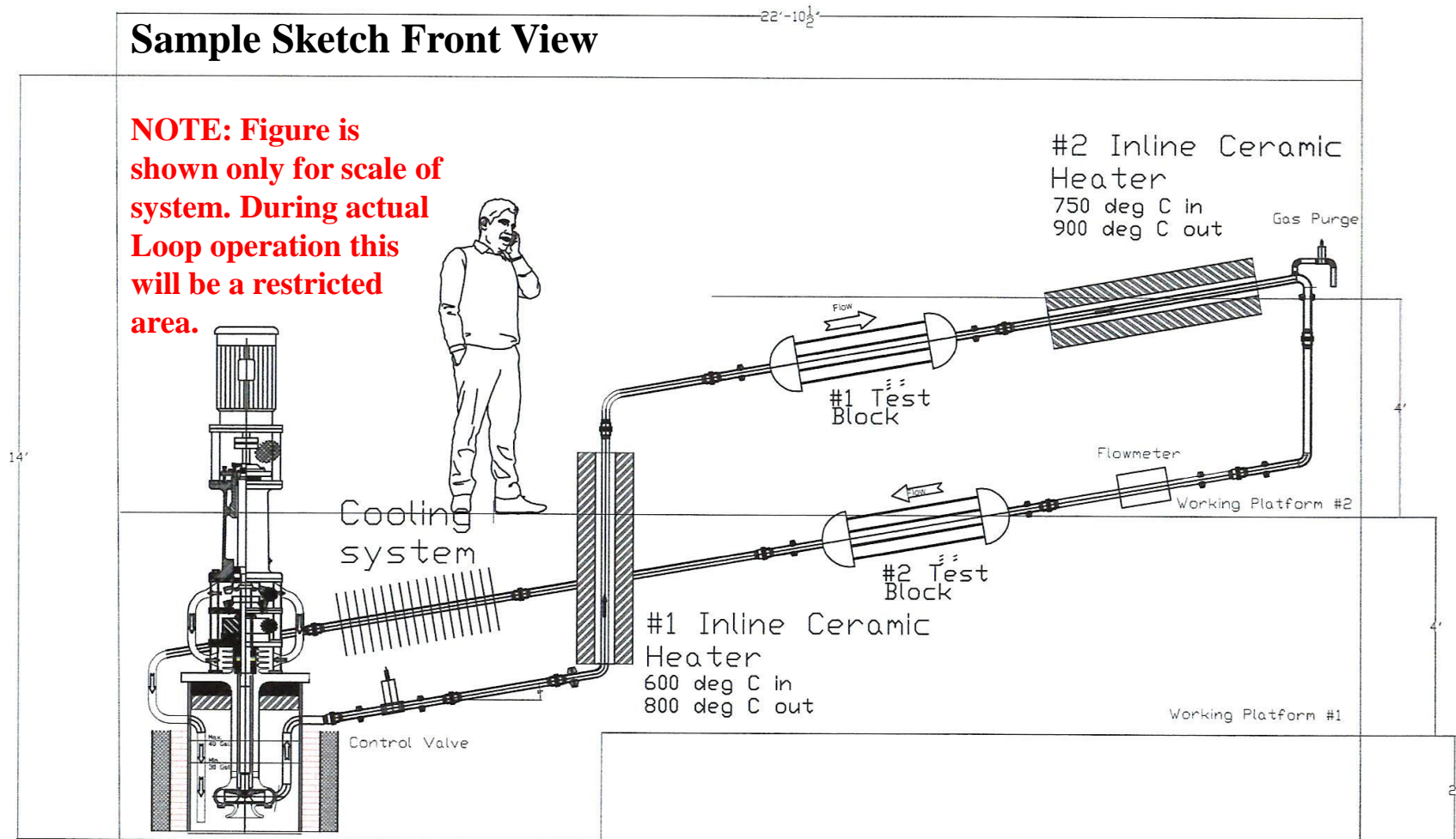
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Guide lines when designing your Molten Salt Test Loop

- 1. Define the lessons to be learned and what concerns need to be de-risked**
- 2. Keep your system simple**
- 3. Benefit from the gained experiences from others to avoid the pit falls in a molten salt loop.**
- 4. Only use experienced designers, engineers and vendors**
- 5. Start with simple 2D sketches then develop 3D models to run your CFD, FEA, Thermal and Stress & Fatigue analysis programs**
- 6. Then BUILD IT!!**

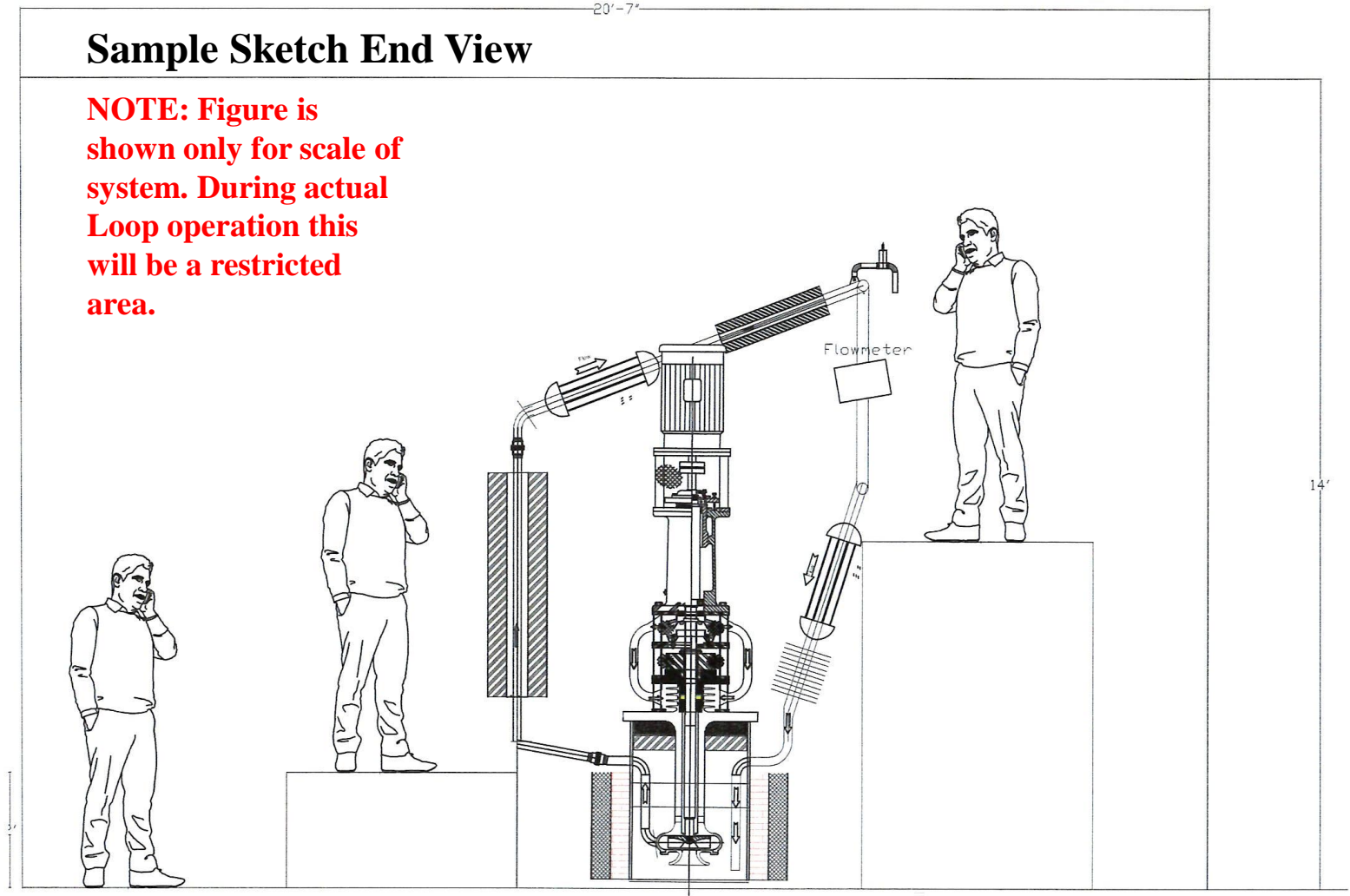
Sample Sketch Front View

NOTE: Figure is shown only for scale of system. During actual Loop operation this will be a restricted area.



Sample Sketch End View

NOTE: Figure is shown only for scale of system. During actual Loop operation this will be a restricted area.





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Thank you for Your Attention
I hope this was Educational
and
If I can be of any help
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