UT-BATTELLE

Mercury Delivery System Issues

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Targetry Teleconference

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Pump Issues

- **Pump adds heat to Hg**
  - **Pump delivers nominal 51 bhp at 23% efficiency (60 bhp max)**
  - **Magnetic coupling losses 5.4 hp**
  - **Heat energy into mercury**
    - **(bhp - mag)*(1 - eff) + mag = 40.5hp (30kw)**
    - **With Vol=12liter, ΔT=2.4°F/sec (1.3°C/sec) due to pump heating only**
- **Max available pump output pressure is 750 psi (50 bar)**
  - **Total system pressure drop 800-850 psi**

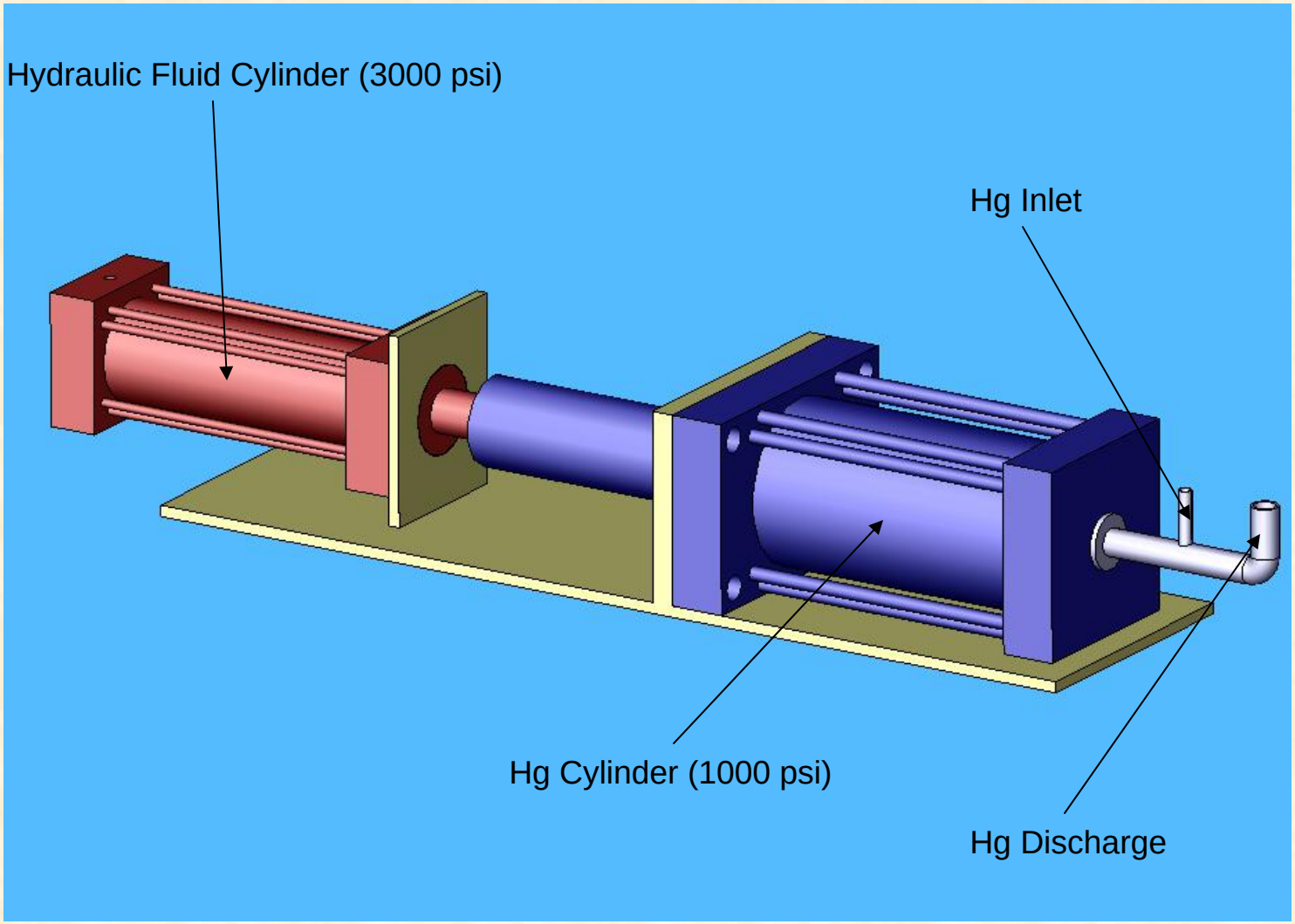
Pump Energy Balance

Pump	Input Energy (hp)	Losses	Lost Energy (hp)	Output Energy (hp)	Heat Direct to Tunnel	Heat Input to Hg	Flow Losses	Total Heat Generated			Energy to Hg	Hg Temp Rise
					BTU/min	BTU/min	BTU/min	BTU/min	KW	HP	BTU/min	°F/sec
Elect Motor	60	60 hp * 5% inefficiency	3	57	127			127	2	3		
Mag Coupling		5.4hp actual coupling loss per vendor data	5.4	51.6	229			229	4	5		
Hg Pump		40.5hp actual pump loss per vendor data	40.5	11.1		1719		1719	30	40	1719	
Hg Flow		800psi*25gpm	12	-1			526	526	9	12	526	
				Totals	356	1719	526	2601	46	61	2245	3.1

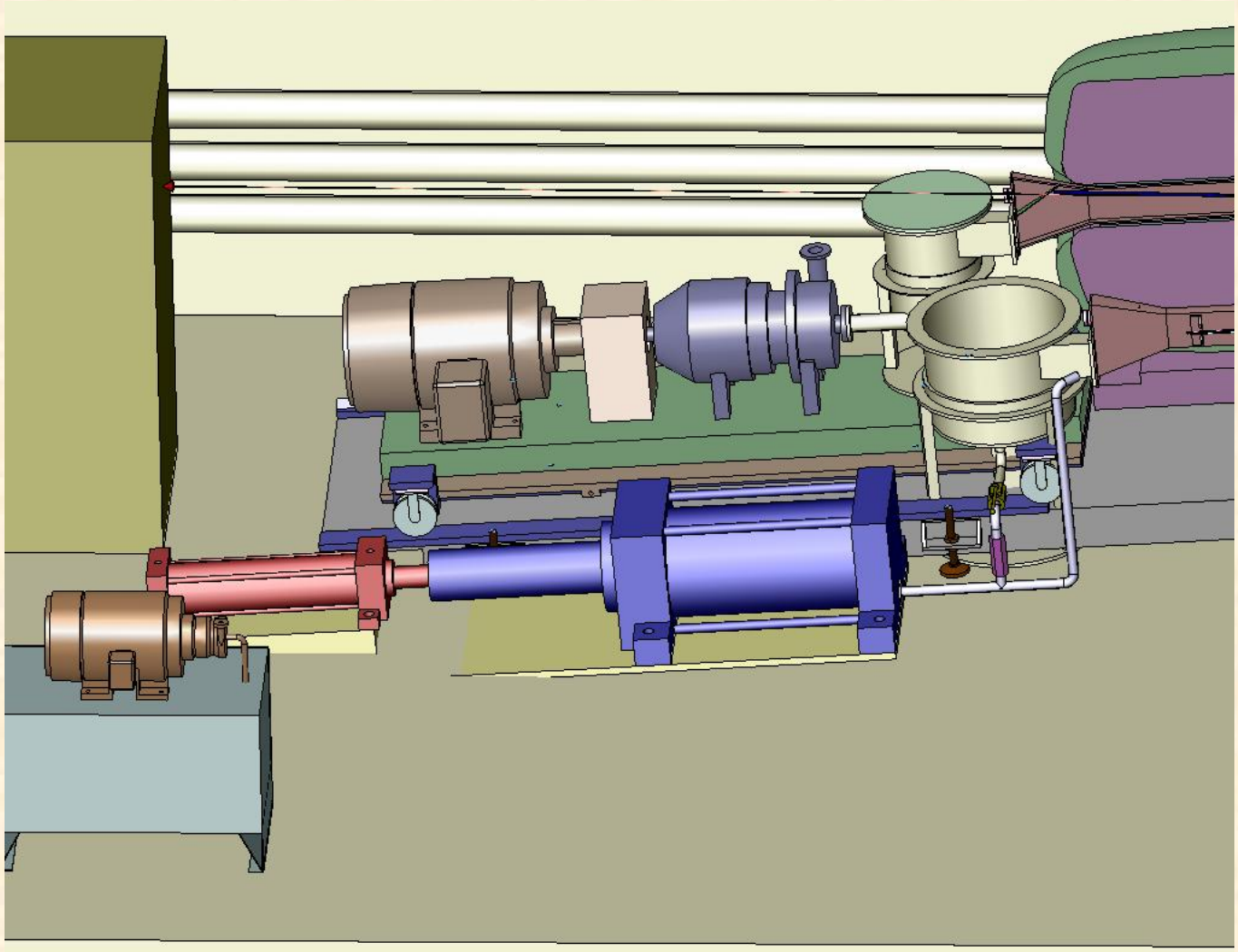
Possible Solutions

- **Heat issue**
  - **Increase Hg volume (ΔT decreases linearly with Hg mass)**
  - **Add heat exchanger for system testing**
  - **Perhaps not needed during CERN tests**
- **Capacity issue**
  - **Investigate alternative Hg delivery systems**
  - **Experiment lends itself to non-continuous flow approach**

Mercury Syringe Concept



Syringe Size Comparison



Syringe Performance Benefits

- **Piston-driven jet has excess capacity to overcome flow losses**
  - **Minor nozzle/piping changes will not affect Hg delivery ability**
  - **Jet characteristics should be identical in both high field & no field conditions**
- **No significant heat imparted to Hg by piston**
  - **Heat losses isolated to hydraulic system**
  - **Flow losses identical to those in pump system**

System Energy Comparison

Pump	Input Energy (hp)	Losses	Lost Energy (hp)	Output Energy (hp)	Heat Direct to Tunnel BTU/min	Heat Input to Hg BTU/min	Flow Losses BTU/min	Total Heat Generated BTU/min	KW	HP	Energy to Hg BTU/min	Hg Temp Rise °F/sec
Elect Motor	60	60 hp * 5% inefficiency	3	57	127			127	2	3		
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				Totals	356	1719	526	2601	46	61	2245	3.1
Syringe												
Elect Motor	20	20 hp * 5% inefficiency	1	19	42			42	1	1		
Hyd Pump		energy performed on piston = press*area*dist/time	11									
Hyd Pump		pump inefficiency	8	11	340			340	6	8		
Piston Energy to Hg		no losses		11								
Hg Flow		800psi*25gpm	12	-1			526	526	9	12	526	
				Totals	382		526	908	16	21	526	0.7

Other Syringe Benefits

- **No heat exchanger required**
- **Syringe design may be smaller than shown, depending on Hg volume required**
  - **25gpm -> 50 liter for 30sec, 25 liter for 15sec**
  - **Concept shown is sized for 30sec jet**
- **Lower power requirements**
  - **Initial vendor discussions estimate 20hp**
- **No added controls issues with this approach**
- **Initial estimate indicates syringe system cost may be much less than pump system**

Hg Delivery System Comparison

Attribute	*Pump*	*Syringe*	*Attribute*	*Pump*	*Syringe*
Continuous Flow	√		**Size**		√*
Hg Inventory	√*		**Power Requirements**		√
Piping Loss Effects		√	**No Heat Exchanger**		√
Jet Consistency In/Out of Field		√	**Controls Complexity**	--	--
Hg Temp Rise		√	**Cost**		√

* Depending on design

Basic Questions / Issues

- **Jet duration directly affects required Hg volume**
  - **Initial sizing based on 30 sec jet**
  - **15T field duration is only 1 sec**
- **Hydraulics in tunnel**
  - **Petroleum, mineral oil, vegetable oil, water/glycol**
  - **What fluids are acceptable (flammability)?**

Recommendations

- **Change baseline Hg delivery system to hydraulic cylinder**
- **Set required jet duration to 10-15 sec**