Brookhaven National Laboratory

U.S. DEPARTMENT of ENERGY

DUNE CRU Cold Test Cryogenic System Design (Nitrogen Delivery)

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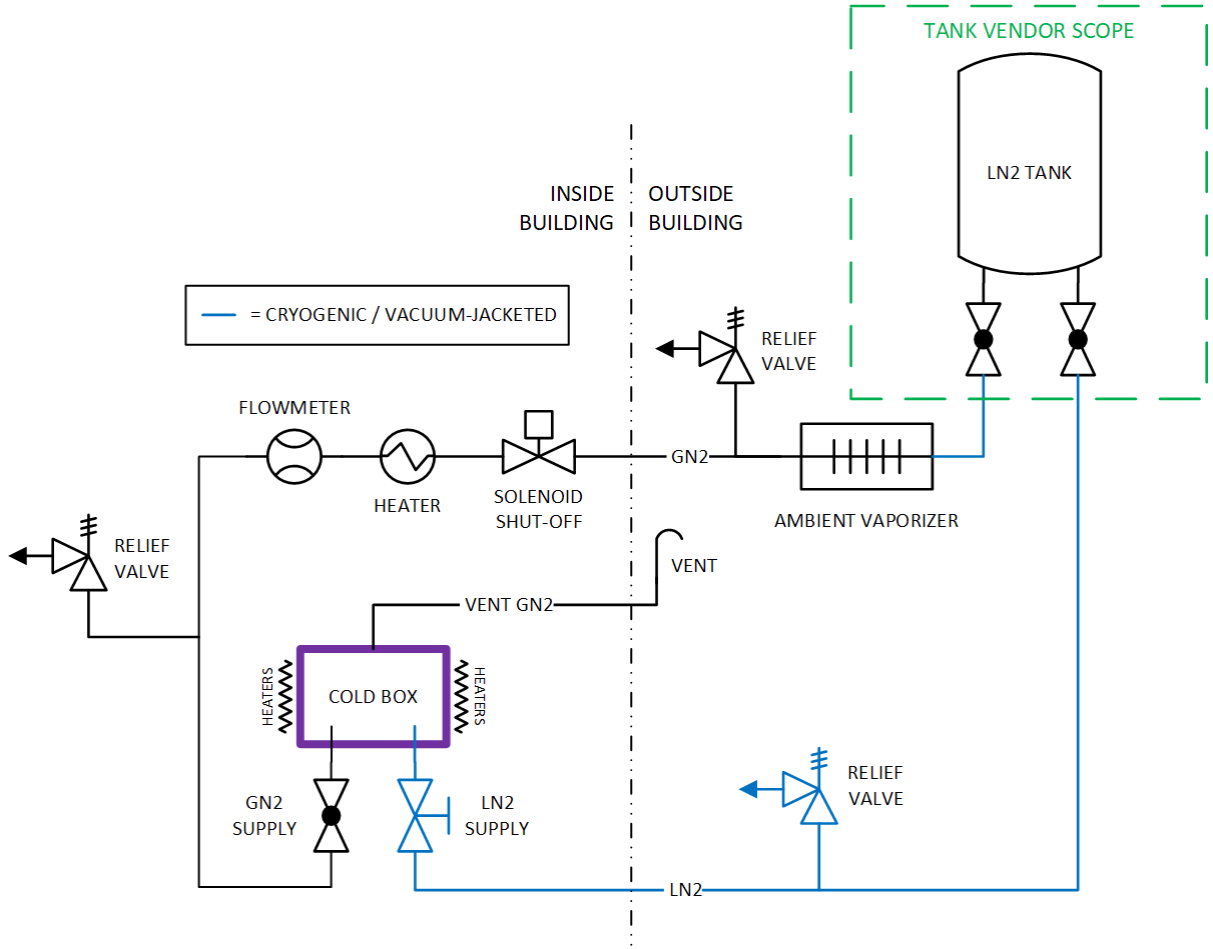
System Overview

- Liquid & gaseous nitrogen supply lines to Cold Box, both fed from LN2 bulk storage
- Vent line to outside building
- Relief valves for trapped volumes
- External heaters on Cold Box



Updates from Previous Approach

- Perform vapor testing (primarily) and half-liquid testing (occasionally) instead of full-liquid testing
  - Significant reduction in LN2 consumption
  - Less gaseous N2 required for warming up
  - Smaller bulk storage tank feasible
- Inexpensive exterior heater tapes vs. submersible heaters
  - Lower power, but significant cost savings and still an additional reduction in LN2 consumption

LN2 Use Estimates / Comparison

Phase	Liquid-only, with submerged heaters	Vapor-only, with no heaters	Vapor-only, with external heaters	Half-liquid, with external heaters
Purge	107 L	107 L	107 L	107 L
Cool Down	636 L	503 L	503 L	569 L
Fill-up	5008 L	399 L	399 L	2037 L
Cold Test	330 L	330 L	330 L	330 L
Boil-off	0 L	0 L	0 L	0 L
Warm-up	3242 L	2974 L	1478 L	1565 L
Total	**9322 L** (~2500 gal*) *Previous estimate ~1900 gal	**4312 L** (~1100 gal)	**2816 L** (~750 gal)	**4608 L** (~1200 gal)

Per cold box cycle, using “dual” (2 CRU) cold box design

Costs & Risks

- Costs reduced primarily by switching to vapor testing, using smaller bulk storage tank, and using alternative heaters
- Unknowns / unaccounted items
  - Facility piping layout – can drive cost of VJ piping (~$400 per foot)
  - Misc. installation materials/labor
    - Electrical power, ODH sensors, etc. - university specific
    - Additional LN2 used for setup testing, re-tests, etc.

Backup slides

Charge Questions

1. Does the design of the cold box and supporting systems meet the technical, scientific, and operational requirements for CRP testing?
2. Is the cold box design sufficiently advanced for preliminary costing and project planning?
3. Are the cold box plans sufficiently advanced to meet the CRP PRR and construction schedule?
4. What are the open design and planning issues? When will the coldbox be ready for a final design review?
5. Has the CRP consortium considered alternative approaches to the cold box design and CRP testing?
6. What are the outstanding risks to the project in terms of cost, schedule, and safety?

LN2 Use Estimates / Comparison

- 80 CRU tested per site (40 cold box cycles)
- $0.21 per liter average LN2 cost

Approach	Test	# of Tests	Total LN2, Liters	Total LN2, $
100% liquid testing	**Full-liquid test**	**40**	**373k**	**$78.3k**
10% liquid testing, 90% vapor testing	*Vapor only test*	*32*	*90k*	*$18.9k*
	Half-liquid test	*8*	*37k*	*$7.7k*
	Total	**40**	**127k**	**$26.6k**
Savings (per tests site)			246k	$51.6k

Cost Estimates – original

Item	Unit Cost ($)	UOM	Qty	Total Cost ($)	Note
LN2 Bulk Storage Tank (monthly rental)	1,985.00	month	60	119,100.00	5-year contract
LN2 Deliveries	0.21	liter	360000	75,600.00	Estimated 30kL/mo, 12mo
LN2 sub-total				*194,700.00*	
Ambient Vaporizer	3,600.00	each	1	3,600.00	Price from recent BNL project (8500 SCFH)
Relief Valves	150.00	each	3	450.00	REGO 19434 PRV or similar
Solenoid Valve	200.00	each	1	200.00	McMaster 3/4" solenoid
Inline Heater	1,000.00	each	1	1,000.00	based on McMaster 1/2" NPT 2.5kW
Flowmeter	1,000.00	each	1	1,000.00	IFM inline thermal flowmeter
Warm valves	150.00	each	2	300.00	~Average for globe valves 1/2"-1" NPT, McMaster-Carr
Vacuum-jacketed valves	3,700.00	each	2	7,400.00	Quote from PHPK 3/4" x 2" VJ globe valve
Vacuum-jacketed piping	400.00	ft	75	30,000.00	Budgetary estimate from Technifab
Small warm piping (<=1") for purge line	20.00	ft	75	1,500.00	3/4" 304 SST sch 40
Large warm pipig (~2-3") for vent line	60.00	ft	50	3,000.00	2-1/2" 304 SST sch 40
Small pipe fittings	20.00	each	10	200.00	elbows, tees, etc.
Large pipe fittings	100.00	each	3	300.00	elbows
Heater (per 5kW) with integrated RTD	9,300.00	each	3	28,000.00	Budgetary quote from Kelvin. Note: Chromalox alternate
Heater controller, circuit breaker, etc.	15,000.00	group	1	15,000.00	Estimate from BNL project experience
Misc. pipe supports & fittings	300.00	group	6	1,800.00	pipe clamps, strut, etc.
Parts sub-total				*93,650.00*	
Total				**288,350.00**	

Notes: ROM cost of materials and nitrogen only, no labor. For dual CRU cold box. Cost is per test site. Excludes cost of cold box itself.

Without using heater

Vapor Test Totals	Time		LN2 Used	
Purge	16.0	hours	214	L
Cool Down	0.93	hours	503	L
Fill-up (n/a)	0.00	hours	0	L
Electronics test	4.0	hours	330	L
Boil-off (n/a)	0.0	hours	0	L
Warm-Up	22.0	hours	2453	L
Total	**42.9**	**hours**	**3499**	**L**
			924.6	Gal

With using heater on cold box

Vapor Test Totals	Time		LN2 Used	
Purge	16.0	hours	214	L
Cool Down	0.93	hours	503	L
Fill-up (n/a)	0.00	hours	0	L
Electronics test	4.0	hours	330	L
Boil-off (n/a)	0.0	hours	0	L
Warm-Up	7.4	hours	1644	L
Total	**28.3**	**hours**	**2691**	**L**
			710.9	Gal

Description	Clarifications	Cost	Results
Saving per test	809 L	0.21 per L (LN2)	170
Heater cost	500*3	500 per heater	1500
Installation cost	500		500
Tests to break even	=(1500+500)/170		11.77
Total cost box cycles	50		50
Total Saving per test	=(170-11.77)/50		$6,495