Gianluca Gemme

LN2 DISTRIBUTION PLANT

Design parameters

- Cryogen — Liquid Nitrogen
- Volume — 200 l (one trap)
- Heat load — 300 W (one trap)
- Trap cold mass — 500 Kg
- Number of traps — 4
- Liquid nitrogen input — 7.10 l/h (one trap)
- Evaporated GN2 — 4.5 Nm^3/h (in standard operation)
- LN2 for cool-down — 650 l
- Working hours (between refilling) 840 h (35 days)

- Operating life — 10 yrs
- Liquid nitrogen cost — 0.094 €/l

Plant general features

- Liquid nitrogen tanks
- Liquid nitrogen transfer lines
- Automatic valve for the regulation of the liquid flow into the trap
- System for the regeneration and baking of the traps (hot GN2)
- GN2 exhaust lines (LN2 evaporation, cool-down, regeneration and baking)

Tank position – central building

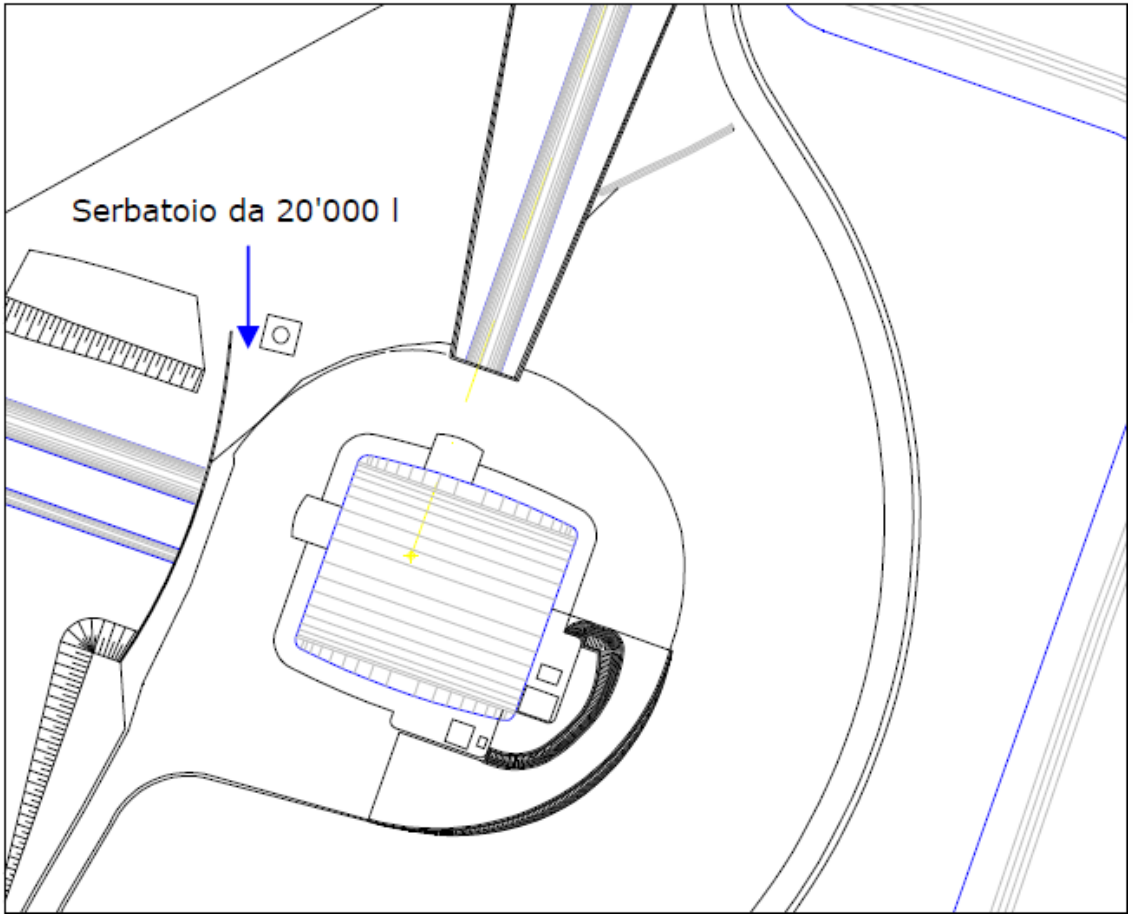
One 20.000 l tank
(> 1 month between refilling)

Advantages:

- **Cheaper than two 10.000 l tanks**
- **Less occupation of space around the central building**
- **Lower loss rate than two smaller tanks**

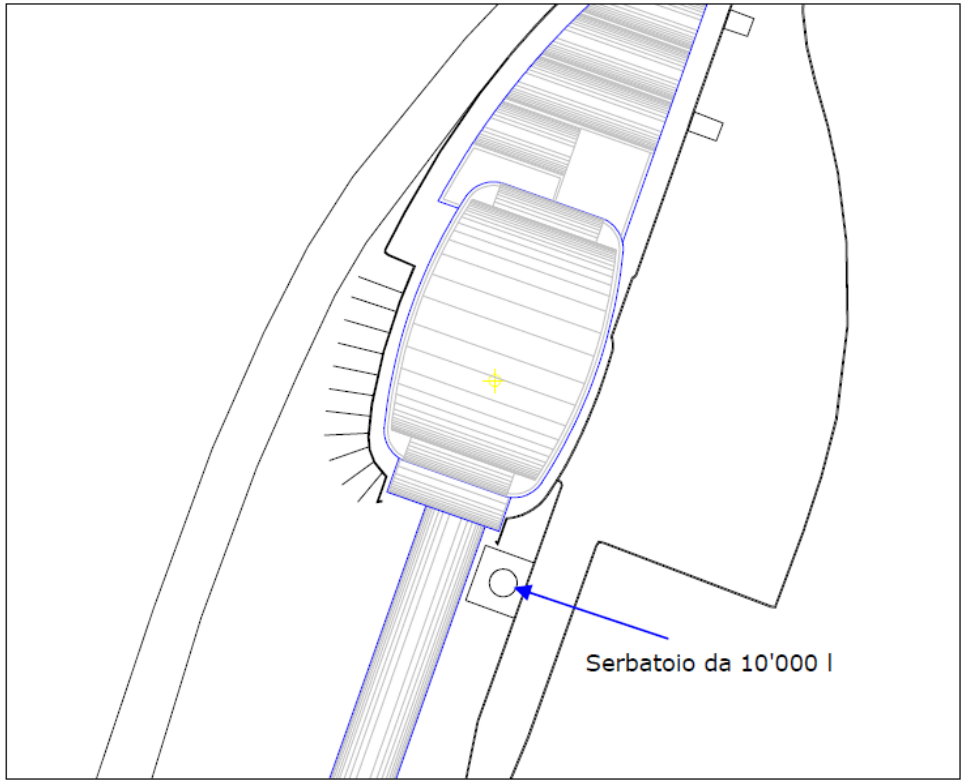
Disadvantages:

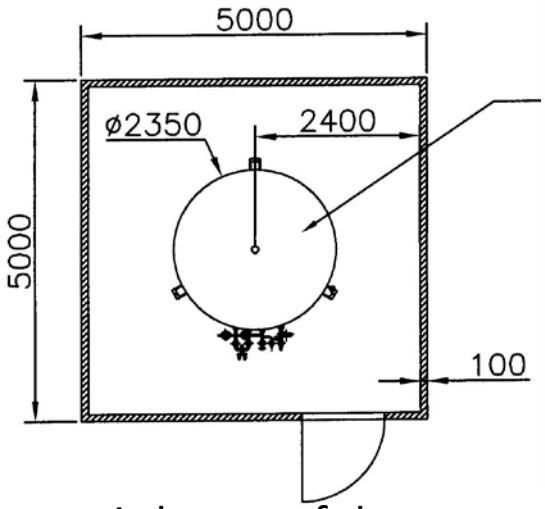
- **Longer transfer lines (50m vs 25m)**



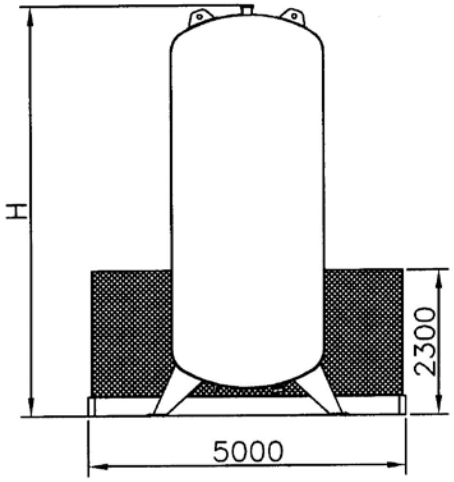
Tank position - end buildings

One 10.000 l tank
(> 1 month between refilling)
Transfer lines approx 22m lenght





Schematic layout of the
delimited area around the tank



Tank height: 9.75m 20.000 l
5.75m 10.000 l

Liquid nitrogen tanks

Super insulated vacuum tank

LN2 loss ~0.04 - 0.05 %/day (5-8 l/d)

Cost € 46,000 (10,000 l)

€ 75,000 (20,000 l)

Standard vacuum tank

LN2 loss ~0.3 %/day (30-50 l/d)

Cost € 32,000 (10,000 l)

€ 46,000 (20,000 l)

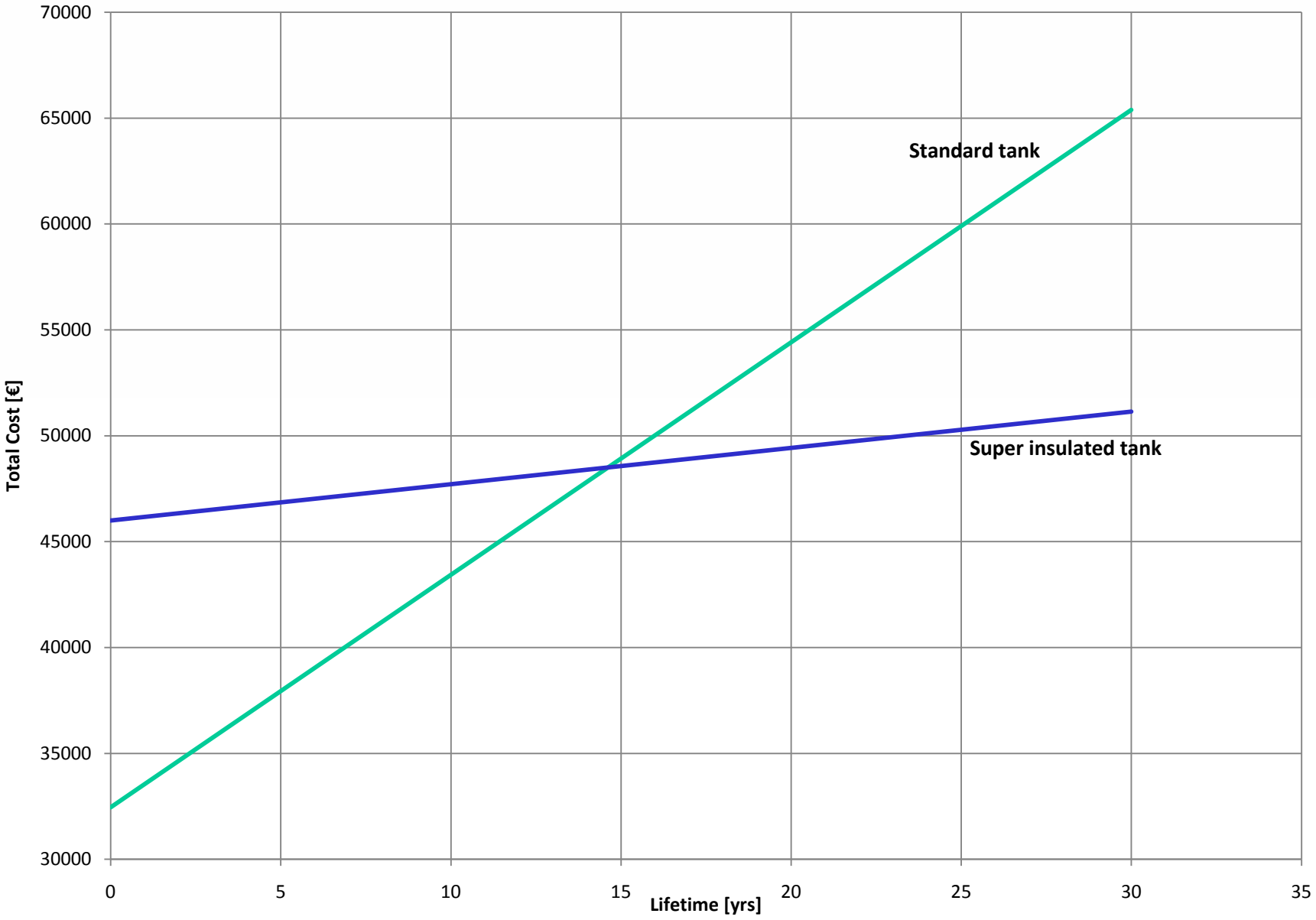
Rented tanks

Standard vacuum tanks

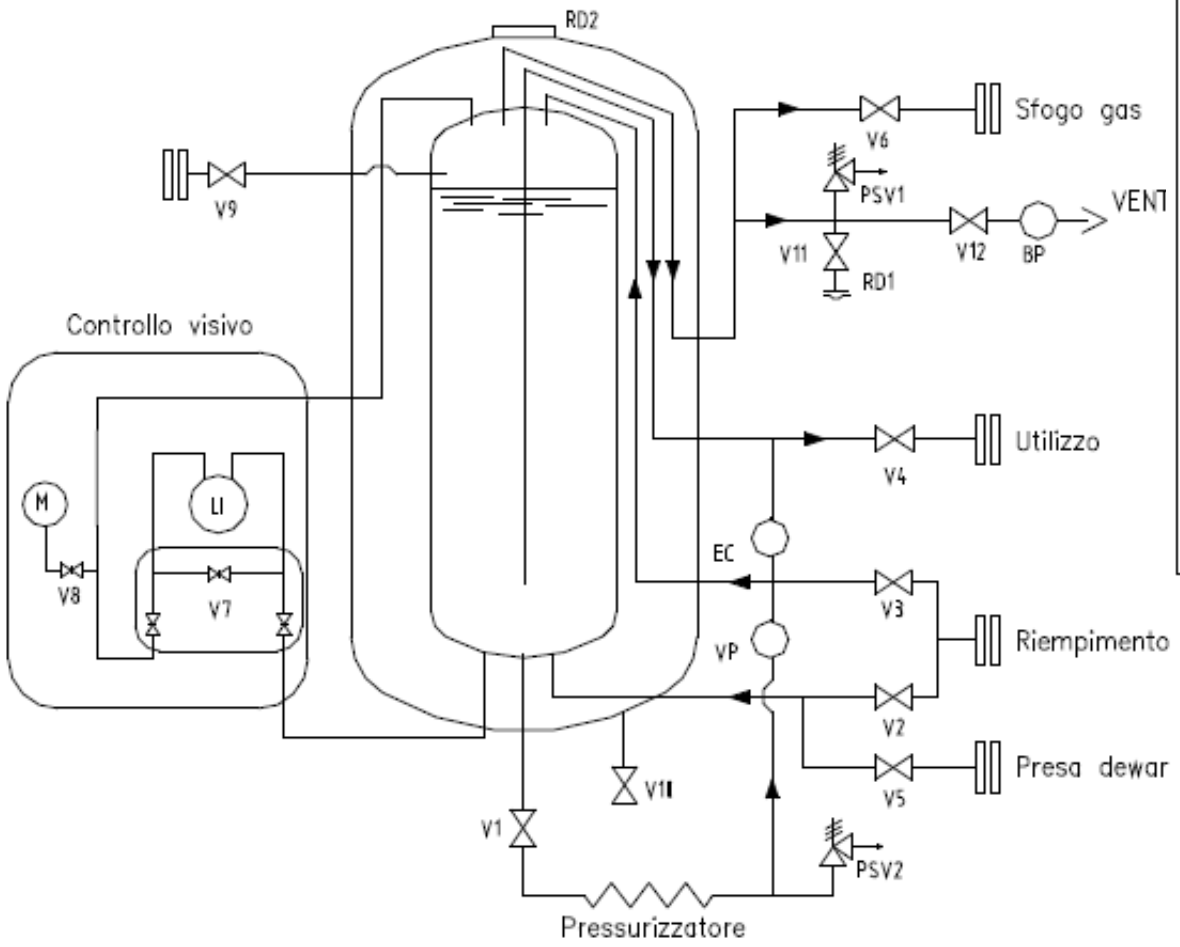
High cost over 10 yrs (approx € 10,500/month)

Maintenance included

Tank self-consumption



Tank layout and instrumentation



V1	Valvola controllo pressurizzatore
V2	Valvola di carico dal basso
V3	Valvola di carico dall' alto
V4	Valvola di utilizzo
V5	Valvola di utilizzo dewar
V6	Valvola di scarico gas
V7	Gruppo di intercettazione indicatore di livello
V8	Valvola controllo manometro
V9	Valvola di troppo pieno
V10	Valvola di ripristino vuoto
V11	Valvola di intercettazione
PSV1	Valvola di sicurezza
PSV2	Valvola di sicurezza
LI	Indicatore di livello
M	Manometro
RD2	Disco di rottura
RD1	Disco di rottura
EC	Economizzatore
VP	Riduttore di pressione
BP	Regolatore di Back pressure

Refilling of the tanks

One refilling per week during maintenance

The time needed will be

45’ for the 20,000 l tank

30’ for the 10,000 l tank

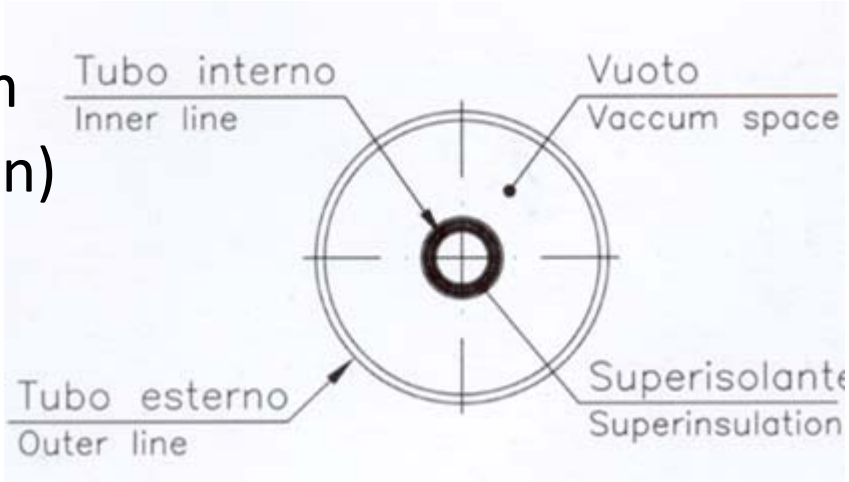
Liquid nitrogen transfer lines

Super insulated lines under vacuum

Stratified flow (gas-liquid separation)

Low losses

Low pressure drop



Linea DN15

dp/m = 1.60E-03 *mbar/m*

Linea	L [m]	Qtot [W/m]	Qgiunto [W/g]	Q [W]	dp tot [mbar]	*Auto-consumo azoto liquido* l/h	Ltot 10 anni
T1_N	54	0.36	1.7	34.7	0.09	0.81	71388
T2_N	22	0.36	1.7	14.2	0.04	0.33	29084
T1_W	52	0.36	1.7	33.5	0.08	0.78	68744
T2_W	22	0.36	1.7	14.2	0.04	0.33	29084

Totale = 198299 *l*

Inner conduit Φ 21.3x1.65 mm ASTM A312 Tp 304

Outer conduit Φ 60.3x1.5 mm AISI 304

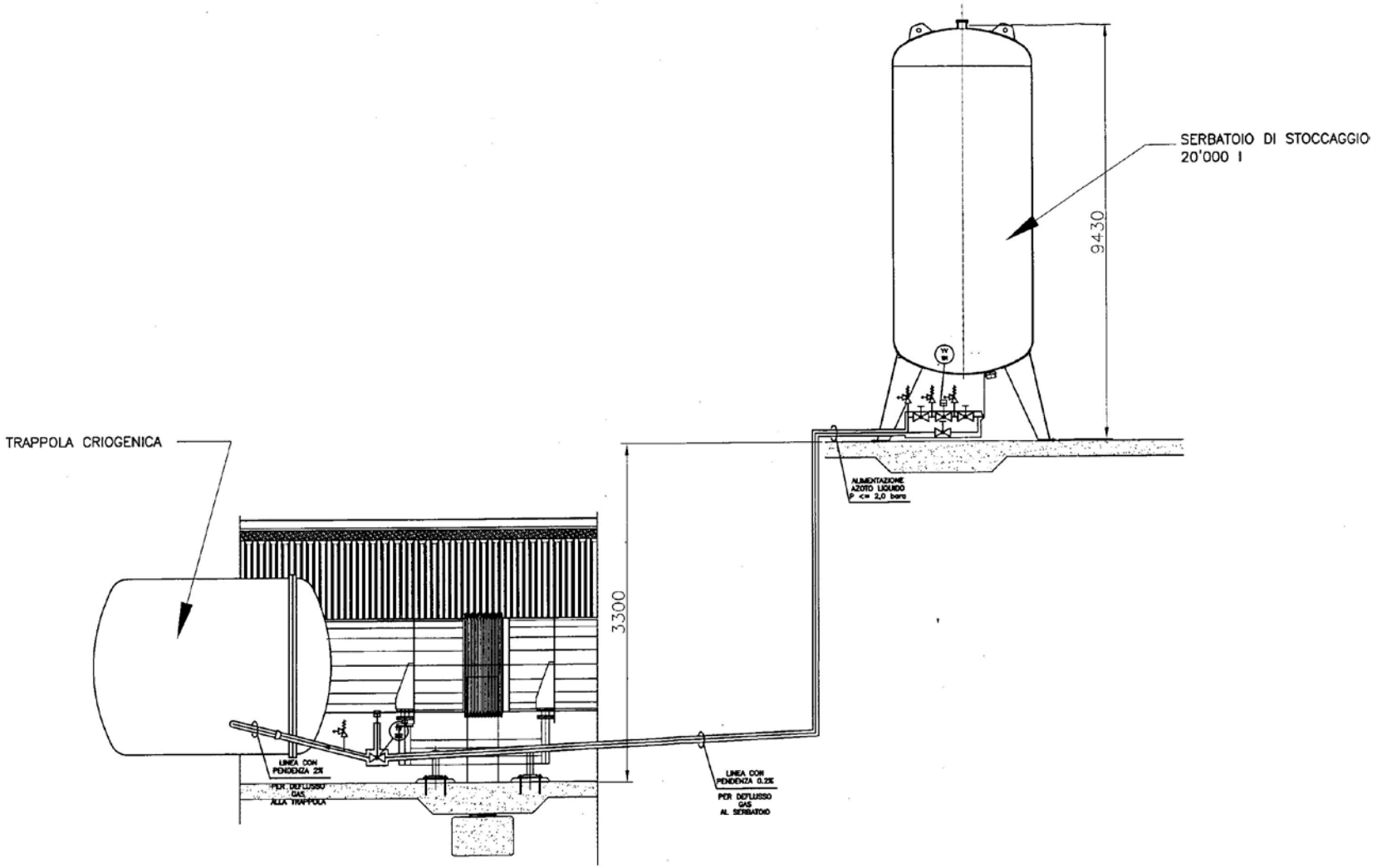
Design pressure 16 bar

Working temperature -196 °C

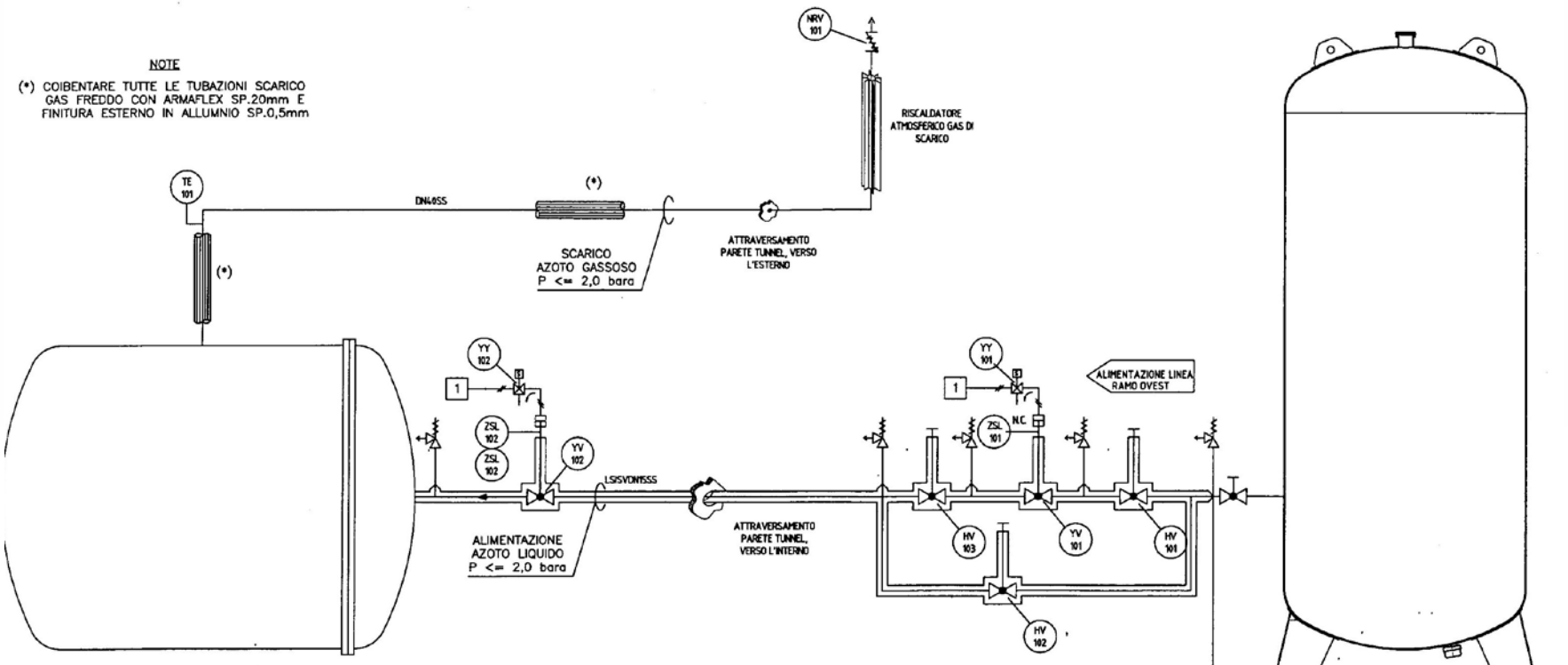
Linear heat loss 0.4 W/m

Linear weight 3.7 Kg/m

Liquid nitrogen transfer lines – central building



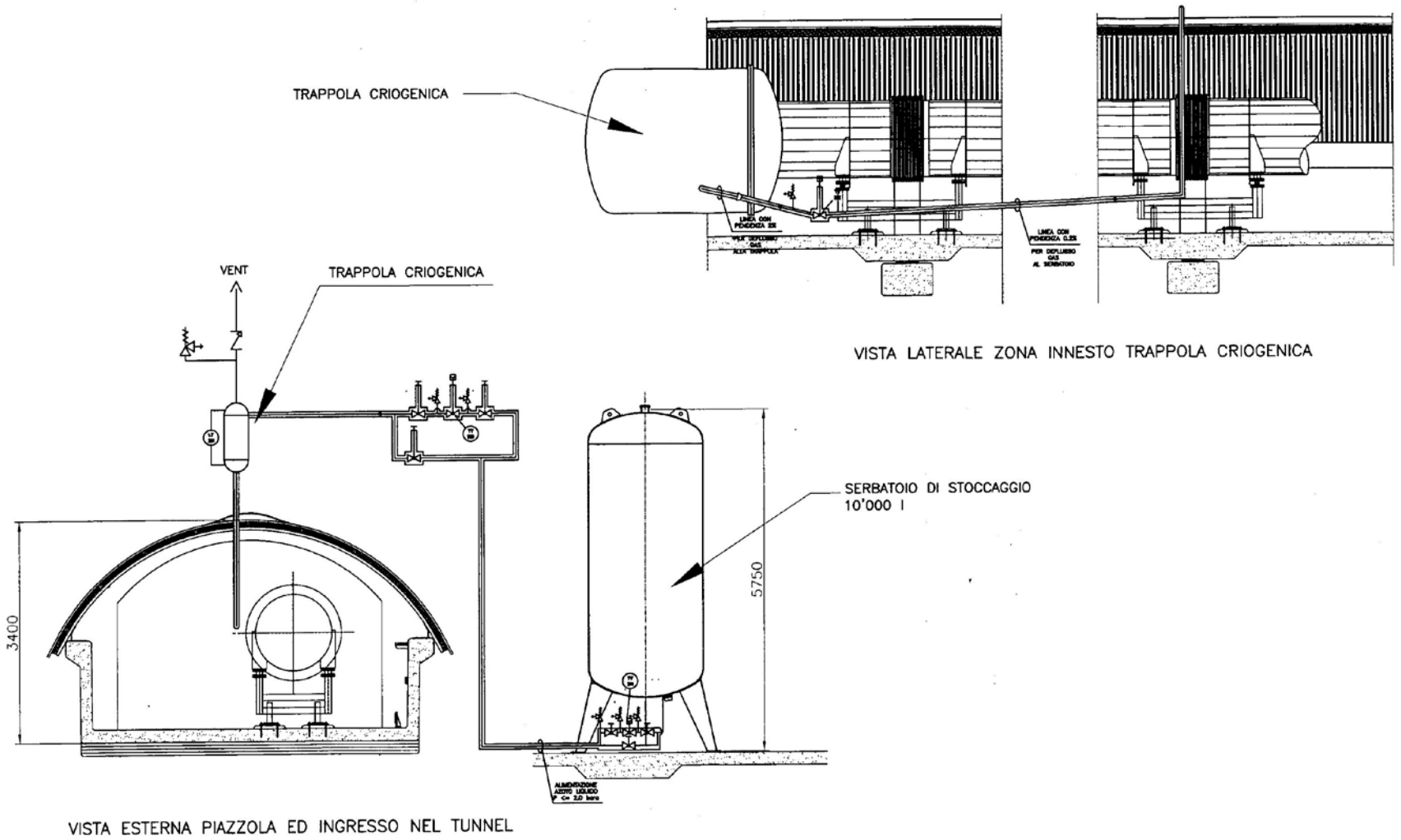
Central building



NRV101	Valvola di non ritorno scarico gas esausti
HV10x	Valvola criogenica super isolata sotto vuoto. By–pass.
YY10x	Elettrovalvole di azionamento attuatori pneumatici.
YV101	Valvola criogenica super isolata sotto vuoto. On/off, NC, pneumatica.
YV102	Valvola criogenica super isolata sotto vuoto. Regolazione, pneumatica.

NRV301	Valvola di non ritorno scarico gas esausti
HV30x	Valvola criogenica super isolata sotto vuoto. By–pass.
YY30x	Elettrovalvole di azionamento attuatori pneumatici.
YV301	Valvola criogenica super isolata sotto vuoto. On/off, NC, pneumatica.
YV302	Valvola criogenica super isolata sotto vuoto. Regolazione, pneumatica.

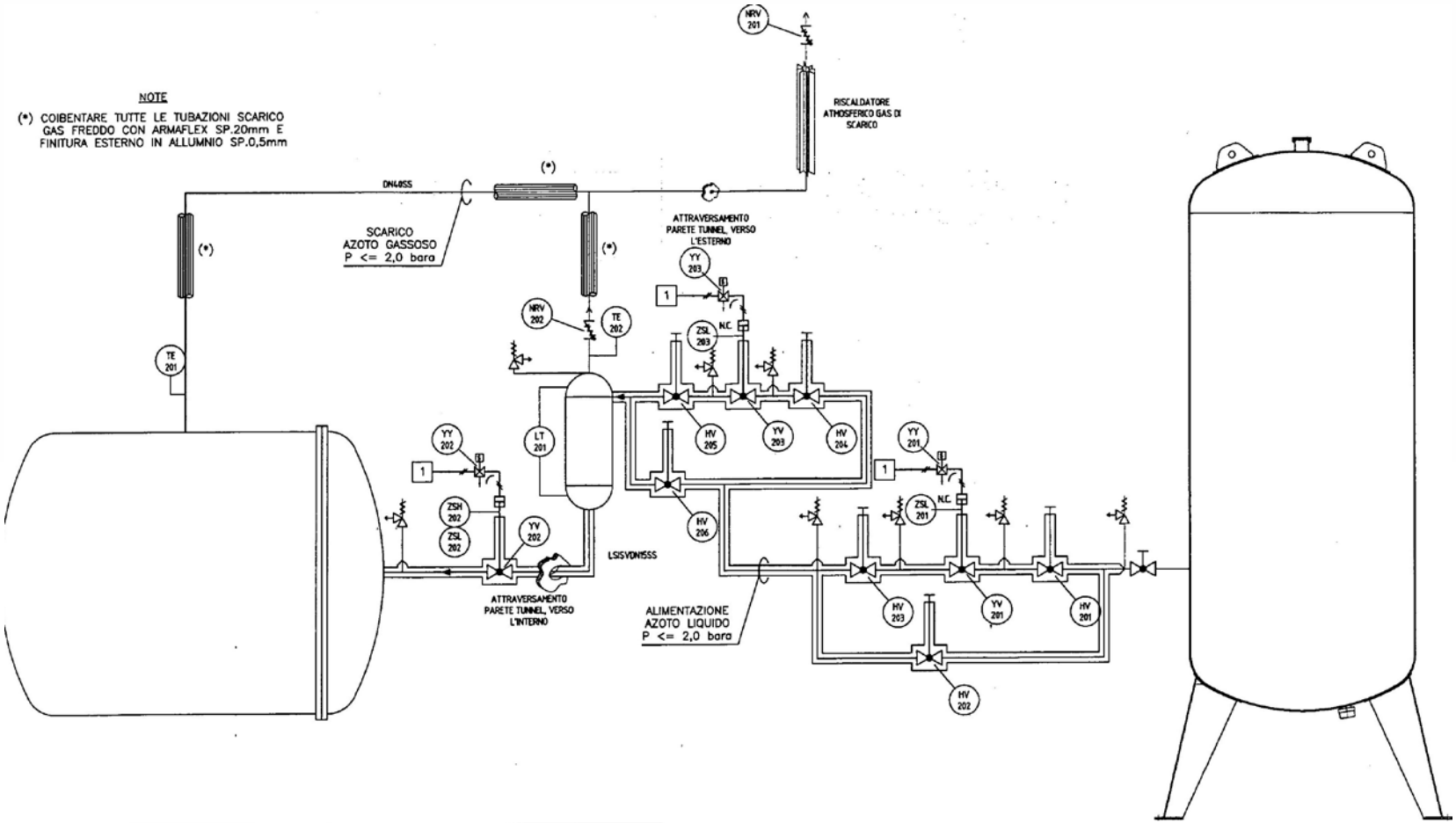
Liquid nitrogen transfer lines – end building



VISTA LATERALE ZONA INNESTO TRAPPOLA CRIOGENICA

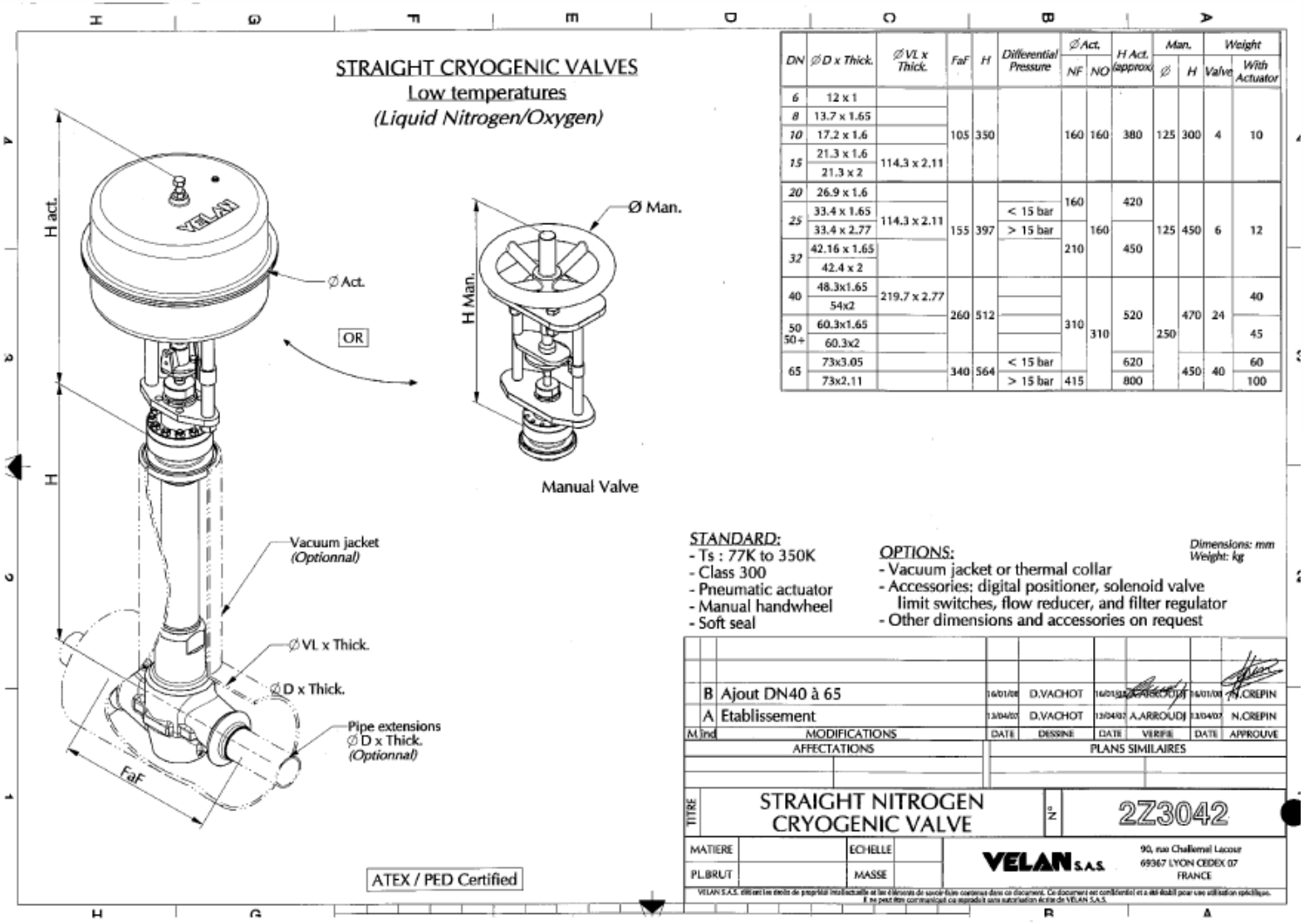
VISTA ESTERNA PIAZZOLA ED INGRESSO NEL TUNNEL

End building



NRV20x	Valvola di non ritorno scarico gas esausti
YY20x	Elettrovalvole di azionamento attuatori pneumatici.
HV20x	Valvola criogenica super isolata sotto vuoto. By-pass.
LT201	Misuro di livello separatore di fase.
YV201	Valvola criogenica super isolata sotto vuoto. On/off, NC, pneumatica.
YV202	Valvola criogenica super isolata sotto vuoto. Regolazione, pneumatica.
YV203	Valvola criogenica super isolata sotto vuoto. On/off, NC, pneumatica.

Cryogenic valve



DN	Ø D x Thick.	Ø VL x Thick.	FaF	H	Differential Pressure	Ø Act. NF	Ø Act. NO	H Act. (approx)	Man. Ø	Man. H	Weight Valve	Weight With Actuator
6	12 x 1											
8	13.7 x 1.65											
10	17.2 x 1.6		105	350		160	160	380	125	300	4	10
15	21.3 x 1.6	114.3 x 2.11										
	21.3 x 2											
20	26.9 x 1.6					160		420				
25	33.4 x 1.65	114.3 x 2.11	155	397	< 15 bar		160		125	450	6	12
	33.4 x 2.77				> 15 bar	210		450				
32	42.16 x 1.65											
	42.4 x 2											
40	48.3x1.65	219.7 x 2.77										40
	54x2		260	512		310	310	520	250	470	24	
50	60.3x1.65											45
50+	60.3x2											
65	73x3.05		340	564	< 15 bar			620		450	40	60
	73x2.11				> 15 bar	415		800				100

STANDARD:
- Ts : 77K to 350K
- Class 300
- Pneumatic actuator
- Manual handwheel
- Soft seal

OPTIONS:
- Vacuum jacket or thermal collar
- Accessories: digital positioner, solenoid valve limit switches, flow reducer, and filter regulator
- Other dimensions and accessories on request

Dimensions: mm
Weight: kg

M.Ind	MODIFICATIONS	DATE	DESSINE	DATE	VERIFIE	DATE	APPROUVE
B	Ajout DN40 à 65	16/01/08	D.VACHOT	16/01/08	A.ARROUDJ	16/01/08	N.CREPIN
A	Etablissement	13/04/07	D.VACHOT	13/04/07	A.ARROUDJ	13/04/07	N.CREPIN

AFFECTATIONS | PLANS SIMILAIRES

TITRE: STRAIGHT NITROGEN CRYOGENIC VALVE
N°: 2Z3042

MATIERE | ECHELLE
P.L.BRUT | MASSE

VELAN S.A.S.
90, rue Challemel Lacour
69367 LYON CEDEX 07
FRANCE

LN2 flash

- The trap works at atmospheric pressure
- At the level of the regulating valve, on the tank side, we have in the worst case (central building) 1.3 bar g
- This causes a sudden expansion across the valve with the formation of 0.12 g/s of GN2 (0.08 m^3/h)
- This is much less than the gas produced into the trap (4.5 m^3/h)
- No problem from the point of view of the operation of the system
- Vibrations?
- A phase separator can anyway be installed

Regeneration and baking

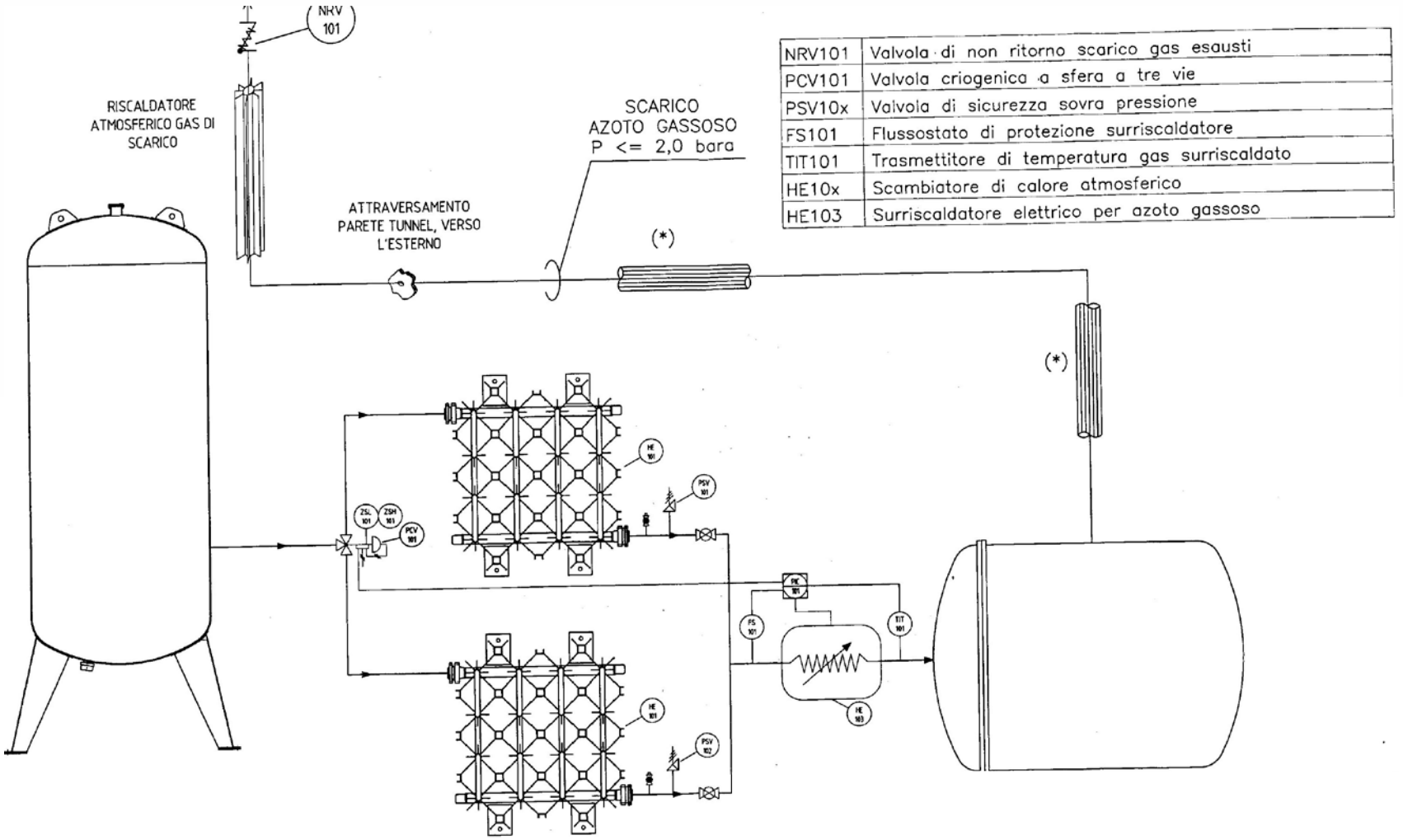
Regeneration (rare event)

Temperature	**50 °C**
Duration	**4 days**
Transient	**6 hours**
Gas load	**415 Nm^3/h (transient)**
	50 Nm^3/h (regime)
LN2 consumption	**3,800 l + 1,870 l/d**

Baking (very rare event)

Temperature	**160 °C**
Duration	**4 days**
Transient	**22 hours**
Gas load	**170 Nm^3/h (transient)**
	50 Nm^3/h (regime)
LN2 consumption	**5,800 l + 1,870 l/d**

Regeneration and baking



NRV101	Valvola di non ritorno scarico gas esausti
PCV101	Valvola criogenica a sfera a tre vie
PSV10x	Valvola di sicurezza sovra pressione
FS101	Flussostato di protezione surriscaldatore
TIT101	Trasmettitore di temperatura gas surriscaldato
HE10x	Scambiatore di calore atmosferico
HE103	Surriscaldatore elettrico per azoto gassoso

Gas exhaust lines

- Max load
  - **500 Nm^3/h cool-down**
  - **415 Nm^3/h regeneration and baking**
- Design pressure 0.5 bar g
- Design temperature -196 - +150 °C
- Nominal diameter DN80

Overall LN2 consumption

	Central building	North building	West building
Transfer line lenght (m)	106	22	22
Line loss (l/d)	38.39	7.97	7.97
Tank size (l)	20.000	10.000	10.000
Tank loss (l/d)	56	32	32
Trap consumption (l/d)	340.8	170.4	170.4
Refilling interval (days)	35	35	35
Total consumption (l)	15.232	7.363	7.363
Cool down (l)	1.680	840	840
Total incl cool down (l)	18.592	9.043	9.043

LN2 plant/trap interfaces

- One DN15 liquid nitrogen input line
- One DN80 vent line
- One DN80 hot gas input line

- Liquid nitrogen level (input to cryogenic valve)

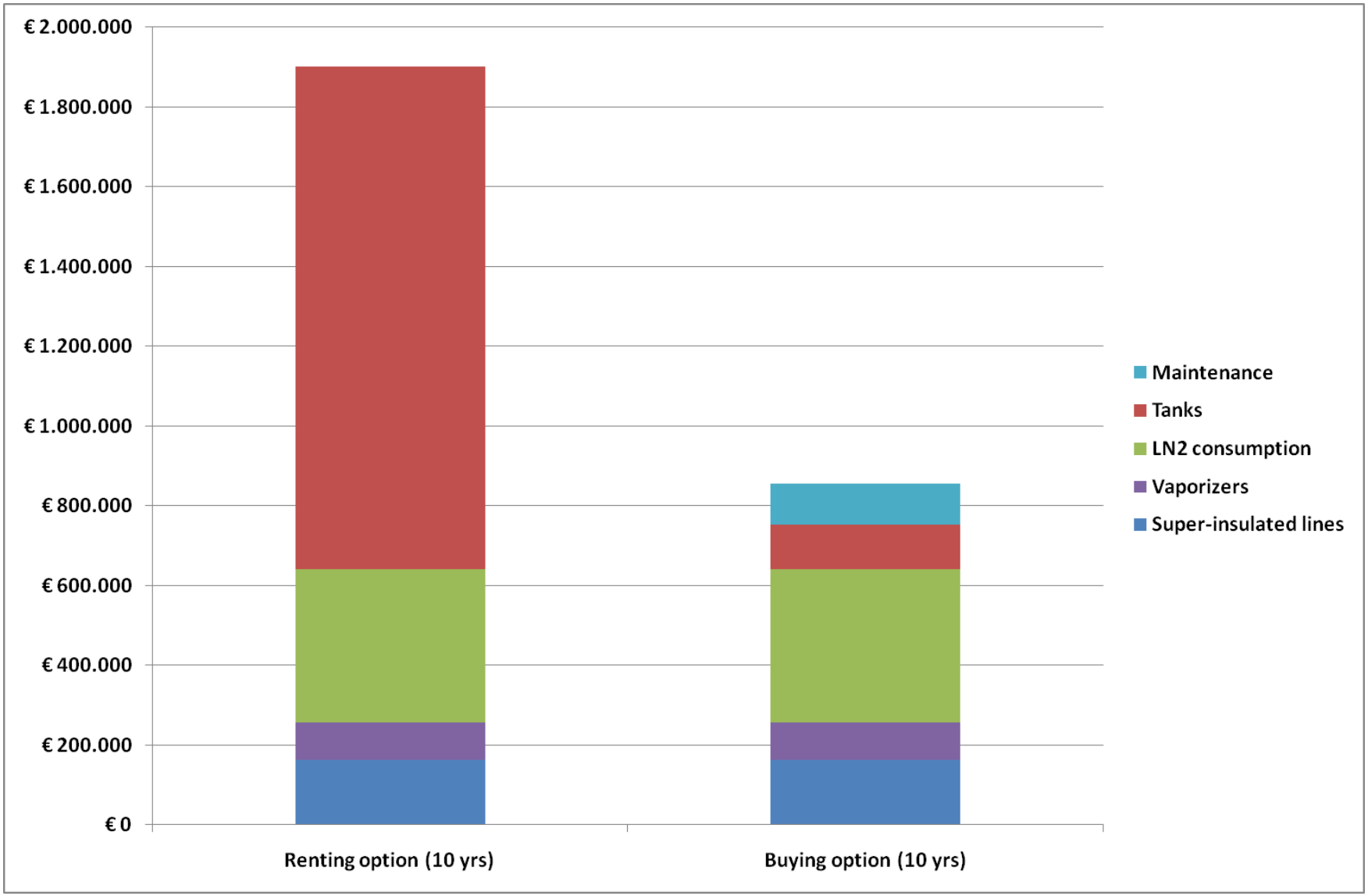
COSTS

Overall cost

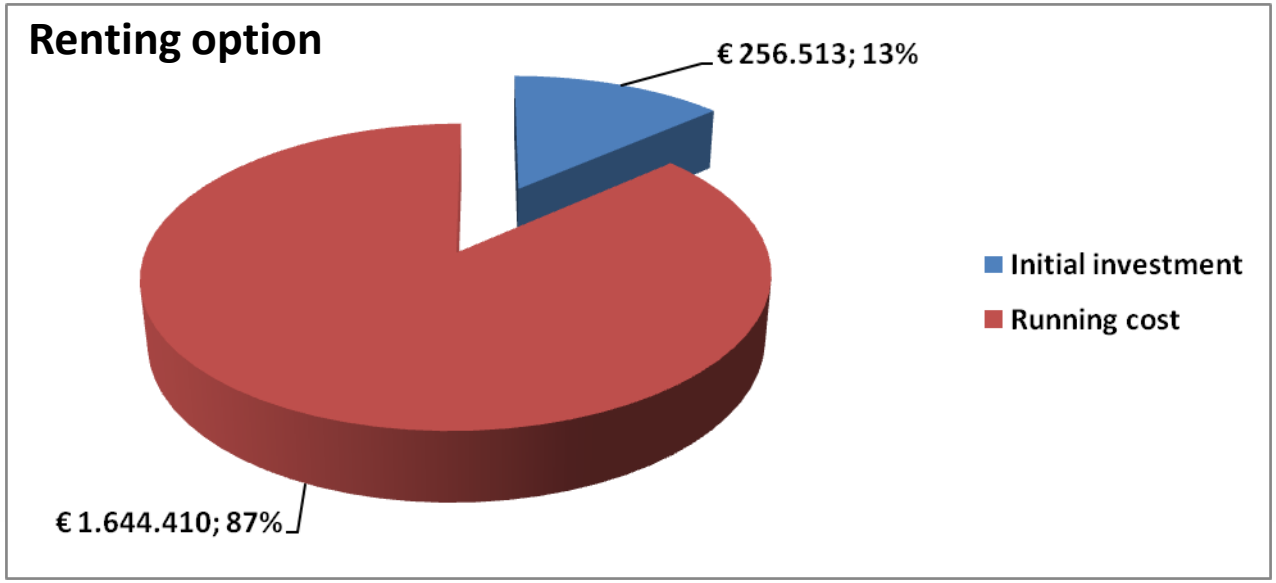
- Operating life 10 yrs
- Liquid nitrogen cost 0.094 €/l

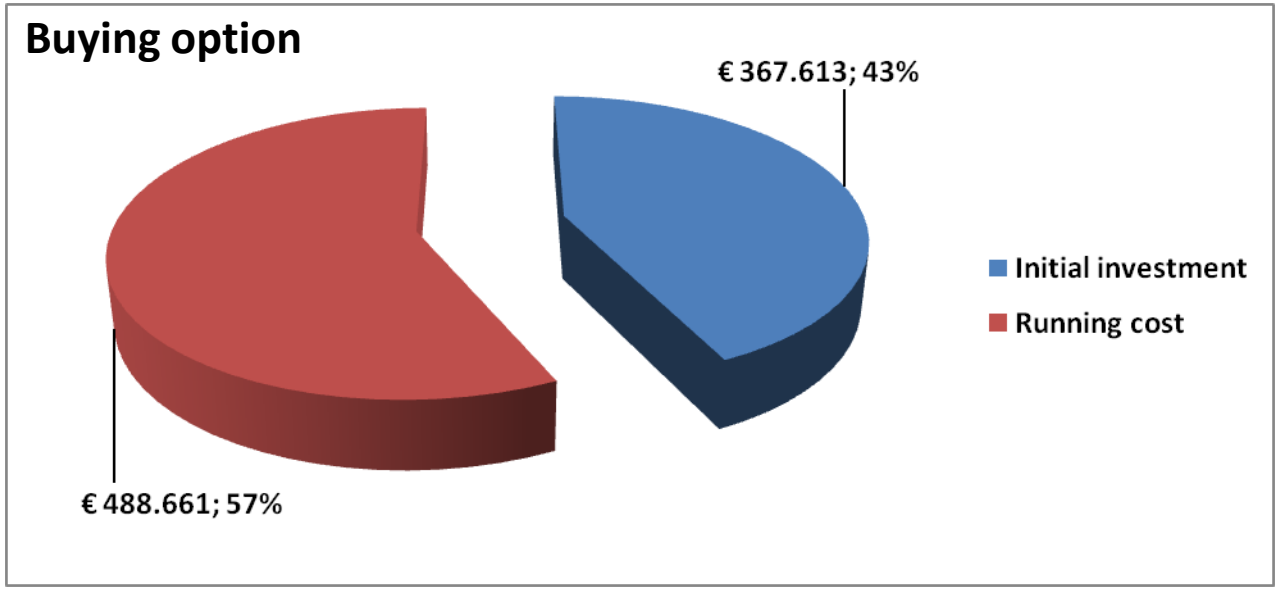
	Rent	**Buy**
Super-insulated lines	k€ 163	k€ 163
LN2 consumption	k€ 384	k€ 384
Vaporizers	k€ 93	k€ 93
Maintenance	k€ 0	k€ 104
Tanks	k€ 1.260	k€ 111
TOTAL	**k€ 1.900**	**k€ 855**
Initial investment	k€ 256 (13%)	k€ 367 (43%)
Running cost	k€ 1.644 (87%)	k€ 488 (57%)

Cost splitting



Initial investment vs. Running costs





Conclusions

- Three LN2 tanks, one for the central building and one for each of the end towers
- Standard vacuum tanks
- Buying the tank looks more convenient than renting them
- Super-insulated transfer lines
- Regeneration and baking system with two atmospheric vaporizers and one heater for each trap

Acknowledgements

EGO Vacuum group
EGO Site&Infrastructure Department
CRIOTEC Impianti