A) Convergence to a common evaporative fluid for the SCT and Pixels

[Greg Hallewell & Vic Vacek]

and

B) Compressor Studies for fluorocarbon vapors.

[Pierre Bonneau & Vic Vacek]

Presented by

Vic Vacek

Basic properties of the candidates → fluorinerts for Atlas Pixel and SCT Cooling System					Added custom mixtures until September 99
Fluorinert	**C3F8**	**C4F10**	**CF3I**	**Custom Mix 3_7**	**Custom Mix 5_5**
Name	octafluoropropane	decafluorobutan	trifluoroiodomethane	C3F8[30%mass] C4F10[70%mass]	C3F8[50%mass] C4F10[50%mass]
Molar mass	188.2	238.03	195.91	220.4	210.1
Triple point temperature [C]	-160.15	-84.15	-153.15	-	
Boiling point temperature [C]	-36.6	-2.09	-22	**Pseudo-critical Properties:**	**Pseudo-critical Properties:**
Critical temperature [C]	71.87	113.18	122.22	98.65	90.1
Critical pressure [bar]	26.8	23.23	38.82	25.24	25.92
Critical density [kg/m^3]	628	599.8	874	608	613.6
Accentric factor [-]	0.325	0.374	0.1796	-	**Custom Mix 7_3**
Dipole at NBP [debye]	0.014	0	0.92	-	C3F8[70%mass] C4F10[30%mass]
Range of applicability					Molar mass = 200.7
Minimal temperature [C]	-160.2	-84.2	-93.2		T_c = 82.32
Maximal temperature [C]	226.9	226.9	146.9		P_c = 26.18
Maximal pressure [bar]	300	300	200		ρ_c = 619.3
Maximal density [kg/m^3]	2049	1823	2614		

Prediction of the thermophysical properties and their verification

⇨ **We are able to generate for the requested fluorinerts**:

⇨ Saturation tables

⇨ Iso-property tables

⇨ Single property at any state point

⇨ Generate appropriate diagrams

⇨ Predict composition of the mixtures and theirs property

Three different compositions of the C3F8/C4F10 custom mixtures were prepared and tested:

Mass fractions:

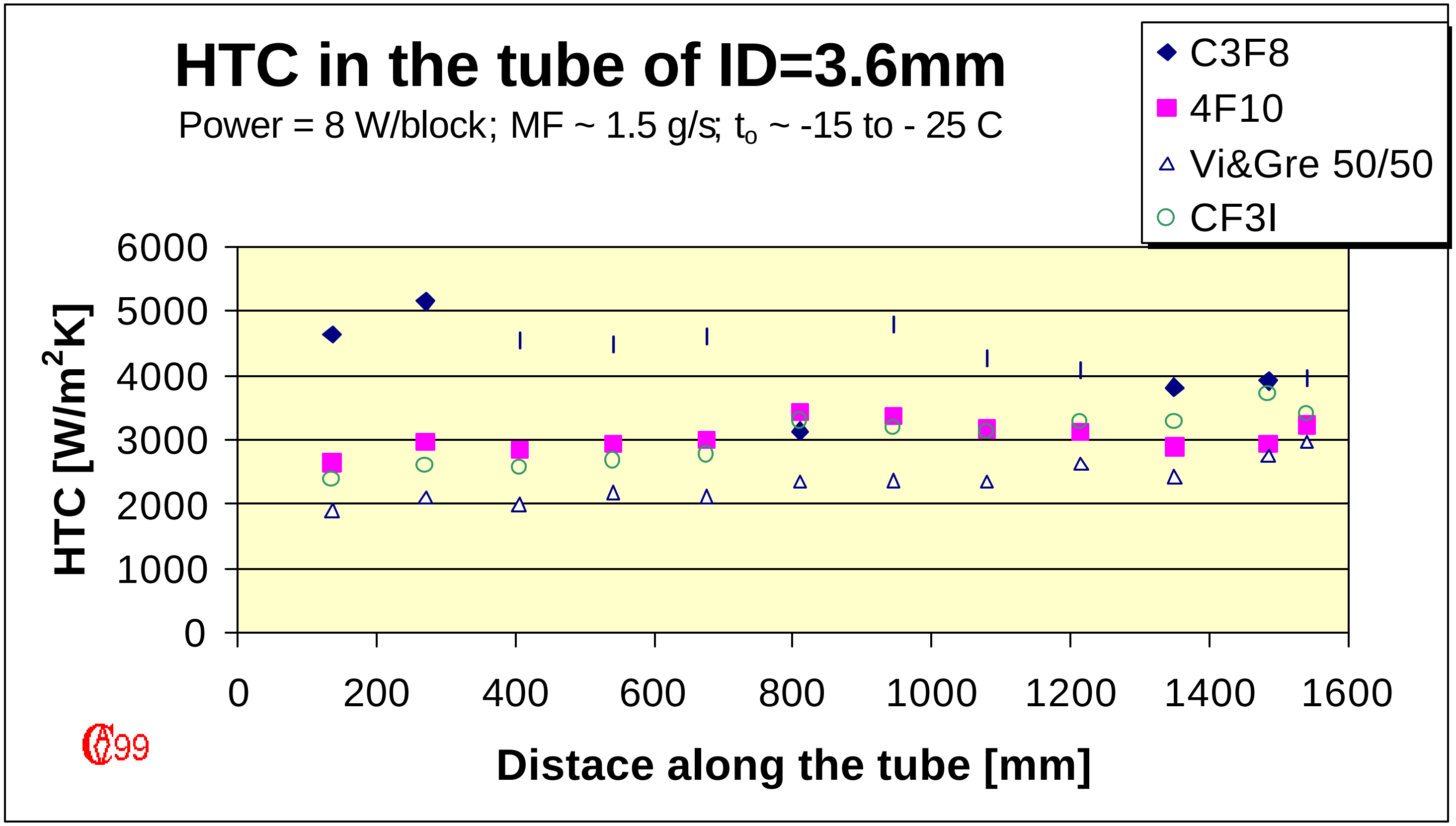
Target composition	Verified composition
(a) 0.3/0.7	[0.30/0.70]
(b) 0.5/0.5	[0.44/0.56]
(c) 0.7/0.3	[0.80/0.20]

⇨ Target composition was verified by gas chromatography analysis and via measurement of the velocity of sound using the Sonar tube developed by G. Hallewell

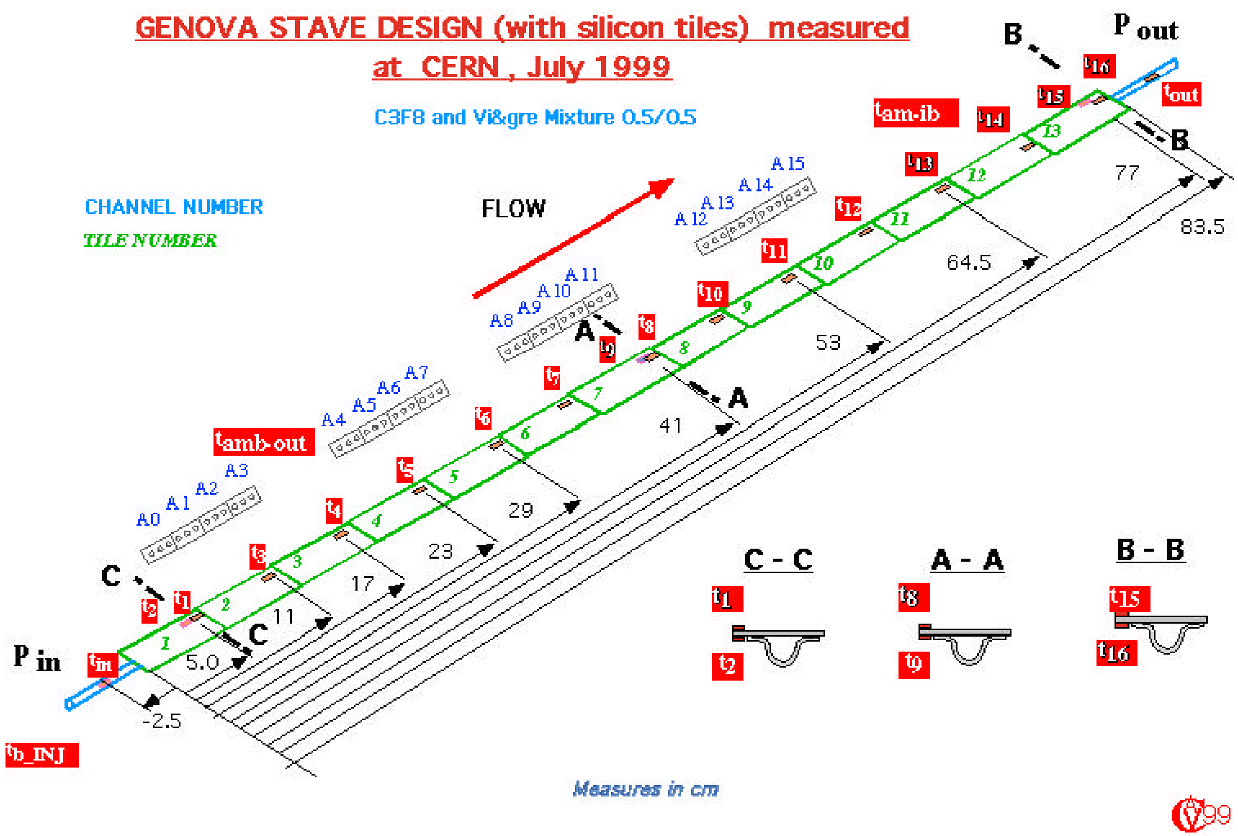
Performed measurements

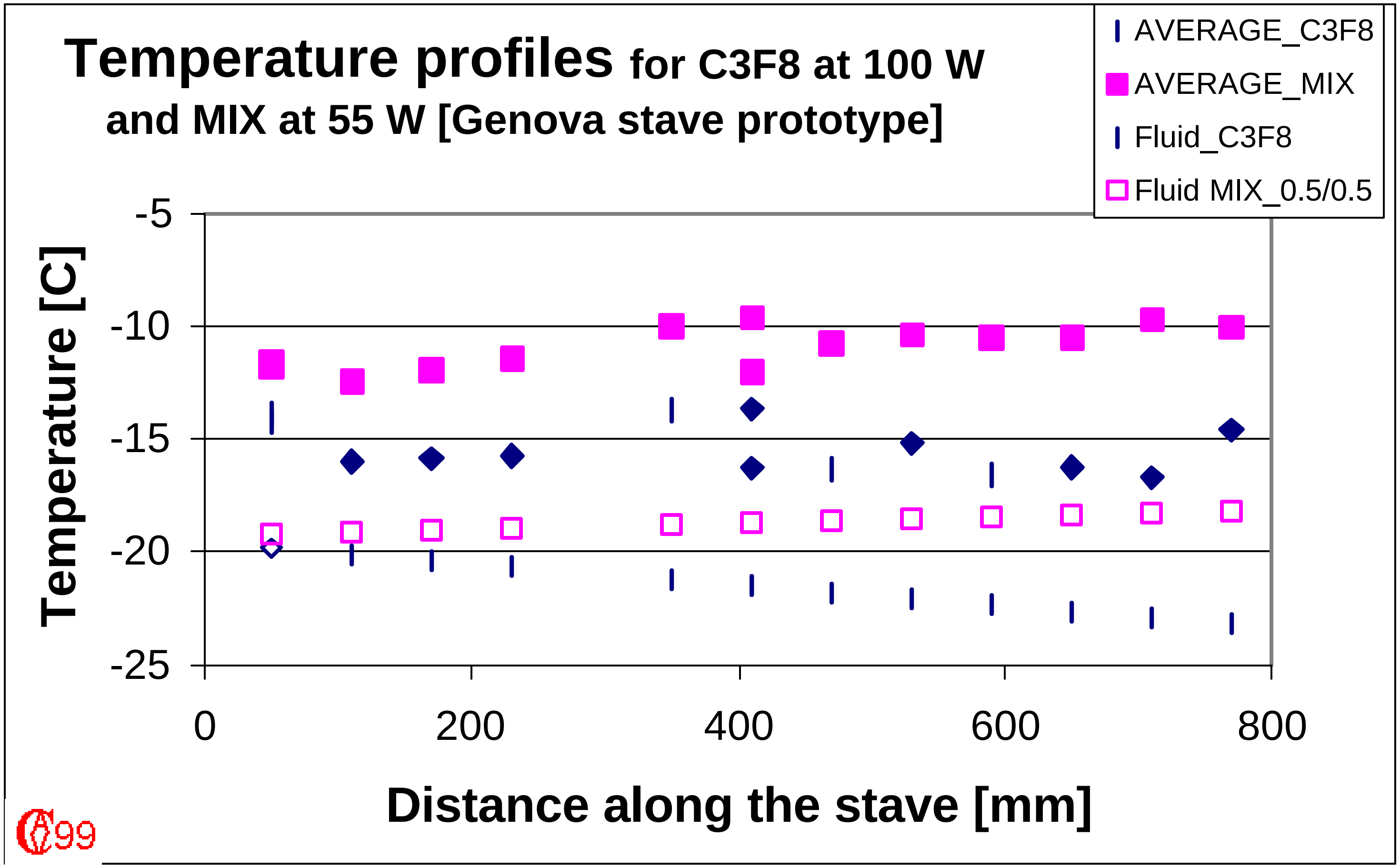
- Temperature profiles along the SCT and Pixel structures were measured
- HTC were measured for all fluids&various technological parameters
    - Different geometries [I.D. or I.D_h.]
    - Different heat fluxes
    - Different mass flows
    - Different sub-cooling
- Needle valve, ruby injectors and capillaries were tested in the evaporative circuits

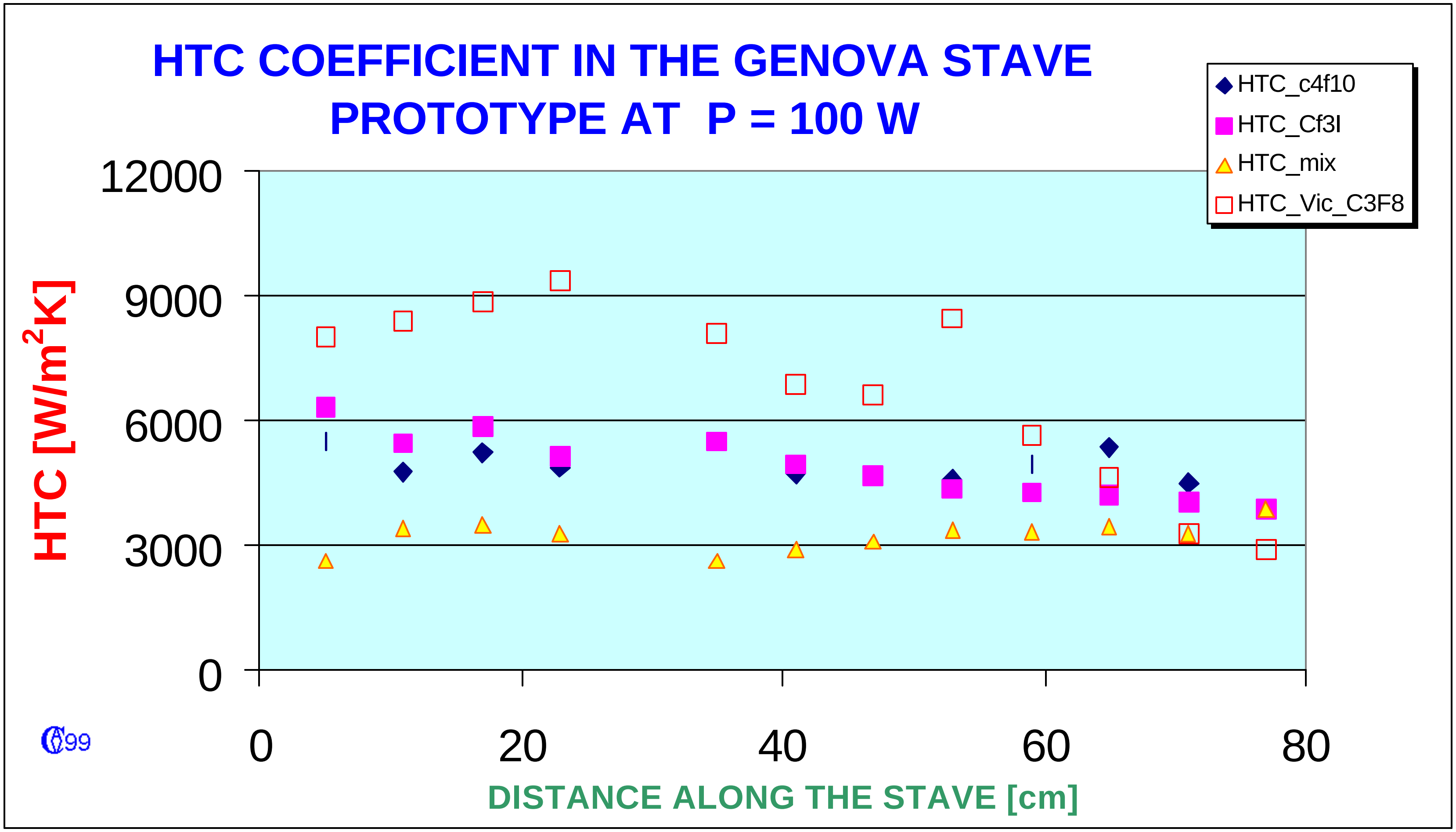
Summary results from HTC coefficient measurements

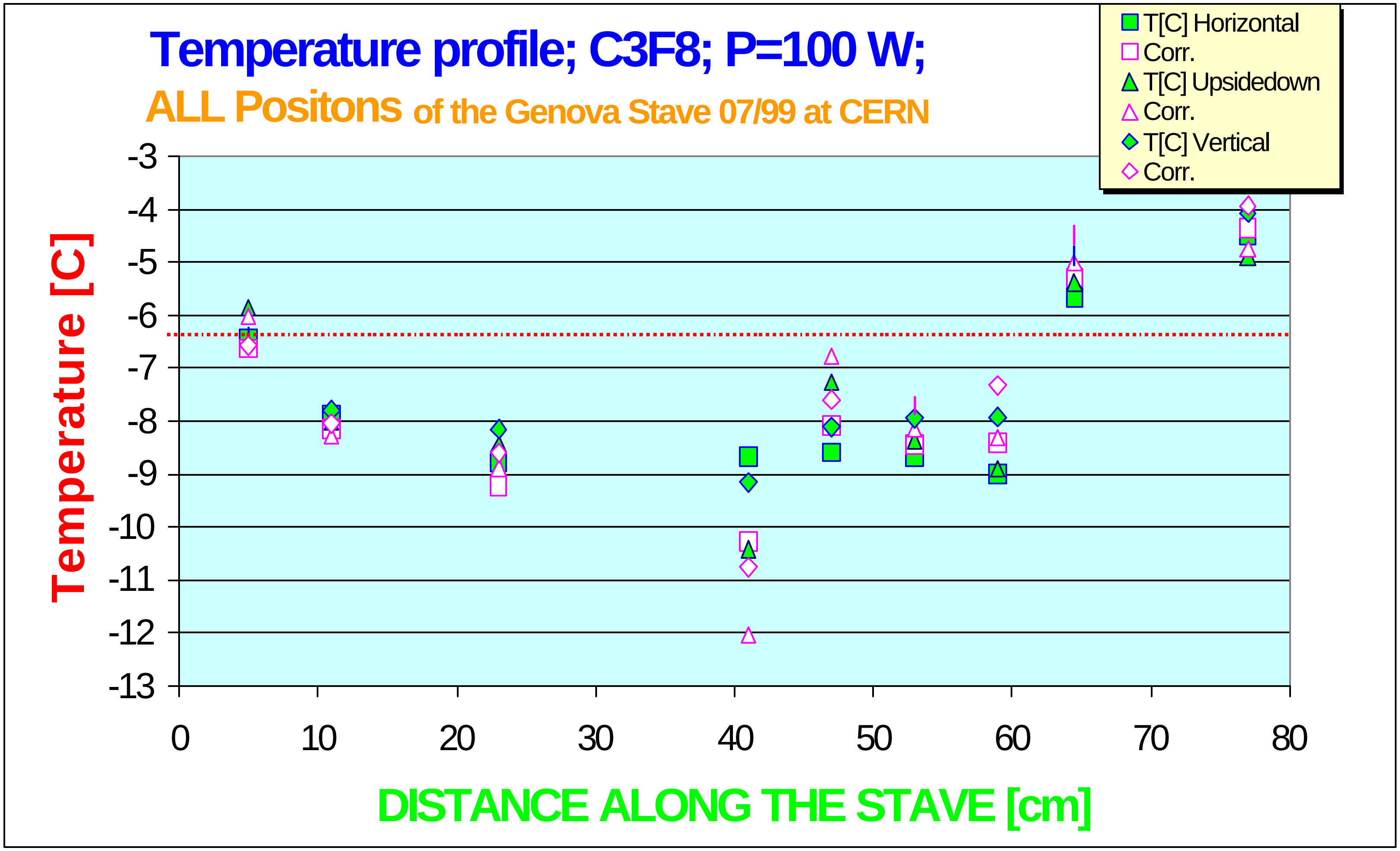


Summary results from Genova stave measurements




Temperature profiles for C3F8 at 100 W and MIX at 55 W [Genova stave prototype]
AVERAGE_C3F8
AVERAGE_MIX
Fluid_C3F8
Fluid MIX_0.5/0.5
-5
-10
-15
-20
-25
Temperature [C]
0
200
400
600
800
Distance along the stave [mm]
99


HTC COEFFICIENT IN THE GENOVA STAVE PROTOTYPE AT P = 100 W
HTC_c4f10
HTC_Cf3I
HTC_mix
HTC_Vic_C3F8
12000
9000
6000
3000
0
HTC [W/m2K]
0
20
40
60
80
DISTANCE ALONG THE STAVE [cm]


Temperature profile; C3F8; P=100 W;
ALL Positons of the Genova Stave 07/99 at CERN
T[C] Horizontal
Corr.
T[C] Upsidedown
Corr.
T[C] Vertical
Corr.
Temperature [C]
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
0
10
20
30
40
50
60
70
80
DISTANCE ALONG THE STAVE [cm]

Conclusions

• From the point of HTC values [averages]:

- In the tube of ID = 3.4 mm

Tube _ I.D. =3.4 mm		HTC [W/m^{2}K]		
FLUID	C3F8	C4F10	MIX_ 50/50	CF3I
AVERAGE	4284	3047	2350	3024
RATIO	1.8	1.3	1.0	1.3

- In the Genova Stave Prototype

Tube _ I.D. =3.4 mm		HTC [W/m^{2}K]		
FLUID	C3F8	C4F10	MIX_ 50/50	CF3I
AVERAGE	6759	4881	3232	4892
RATIO	2.1	1.5	1.0	1.5

• Other aspects are to be considered:

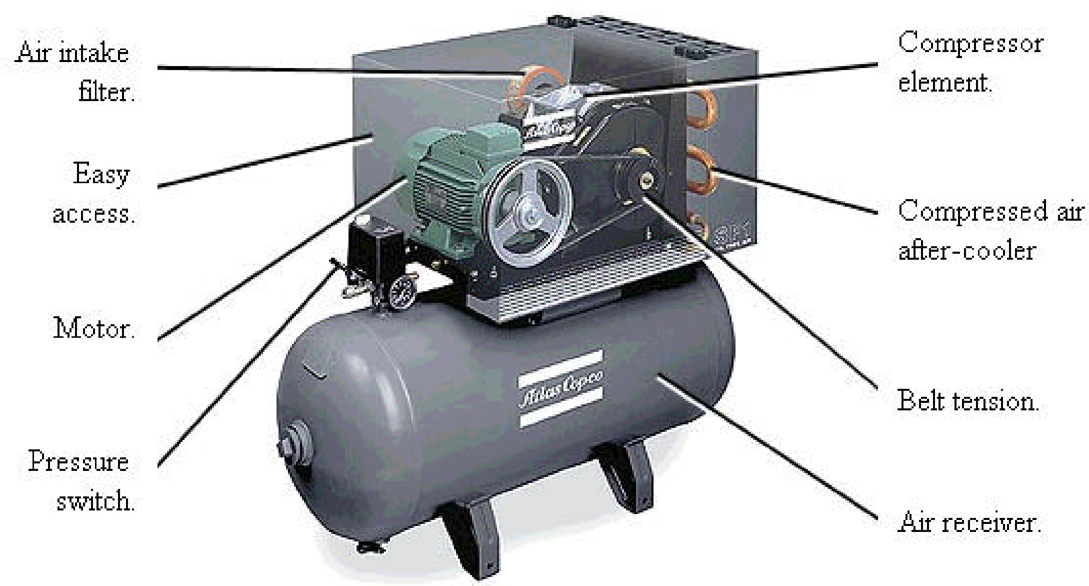
- Pressure limits for the structure
- Pressure losses within connecting pipes
- Temperature ranges [i.e. insulation matters etc.]
- Availability of the other components of the cooling circuit for certain fluid
- Compatibility with used materials
- Safety and environmental aspects
-
-
- Etc.

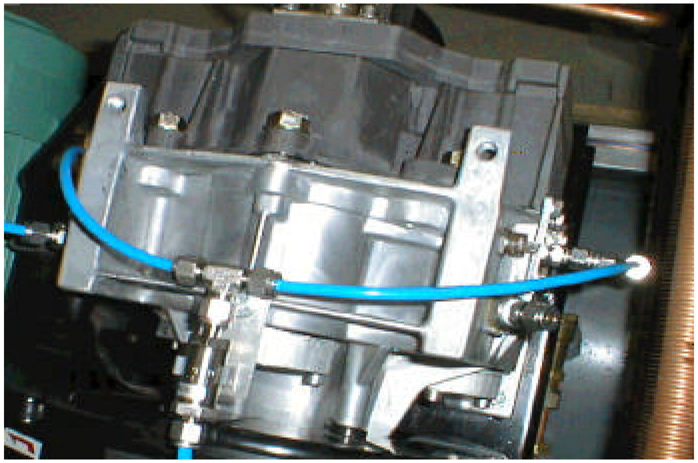
- HTC coefficient is not the only priority !!!

Compressor studies for fluorocarbon vapors.

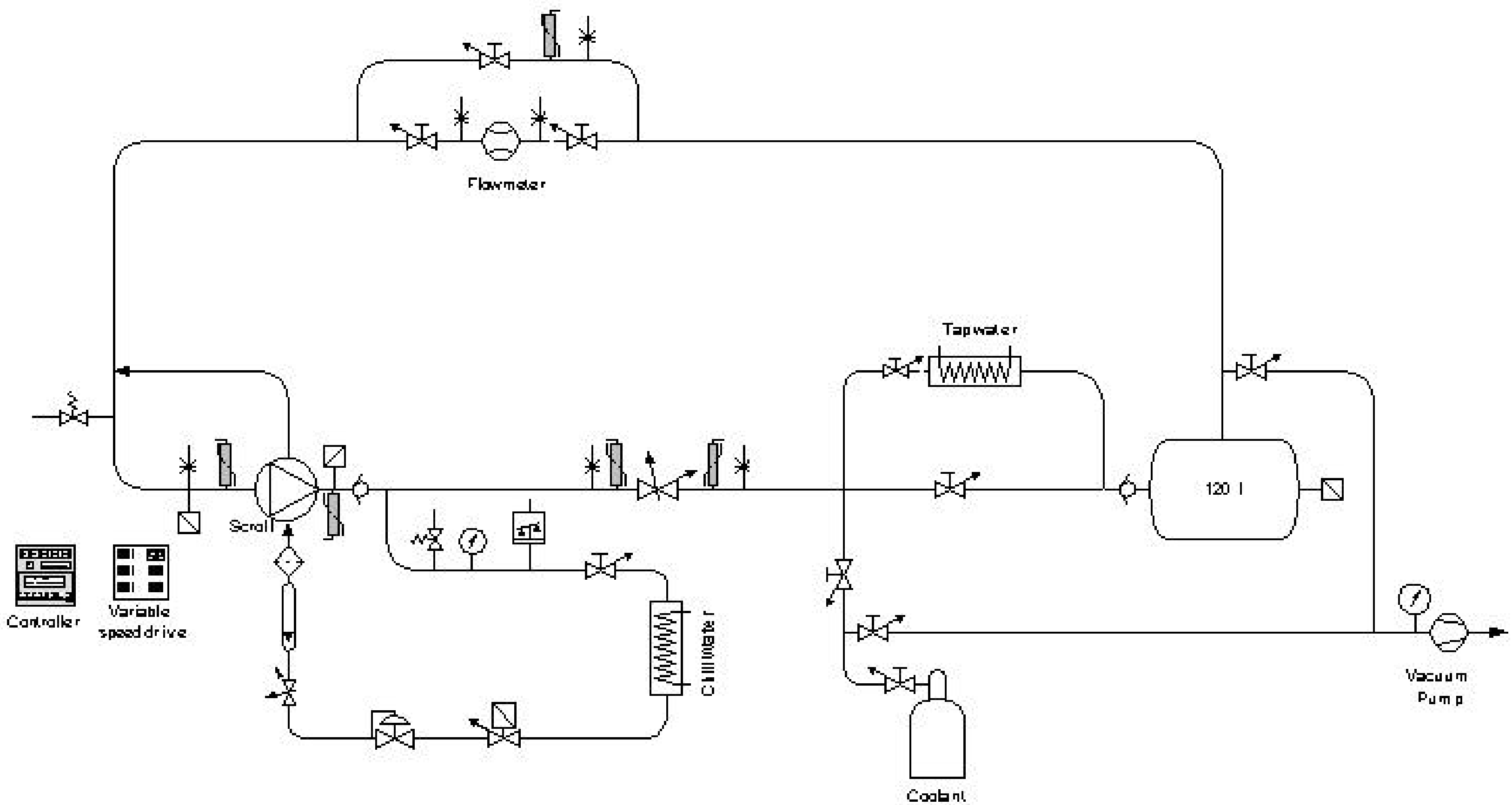
- Dry scroll compressor Atlas Copco SF4-8-120

Main modifications

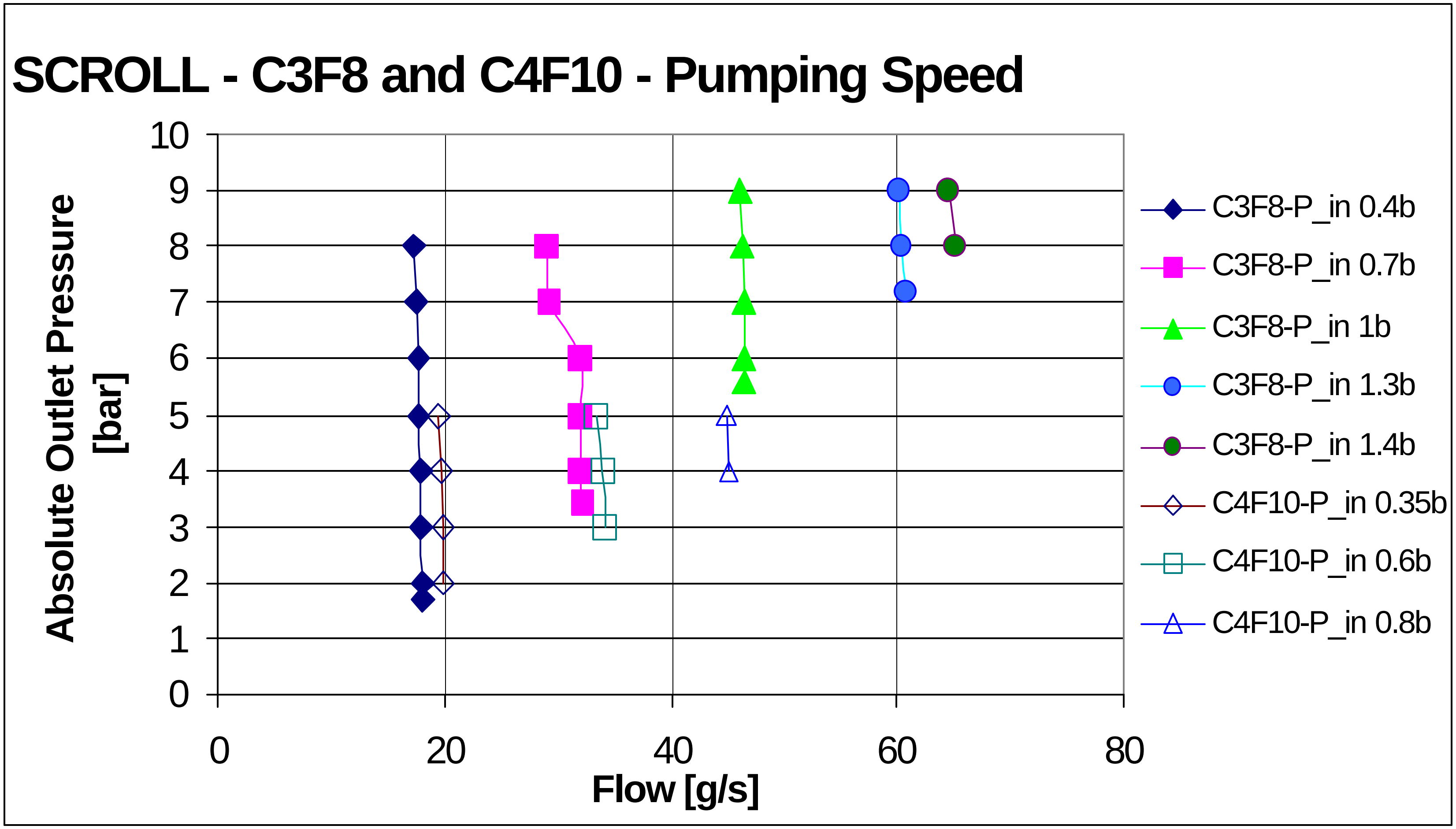




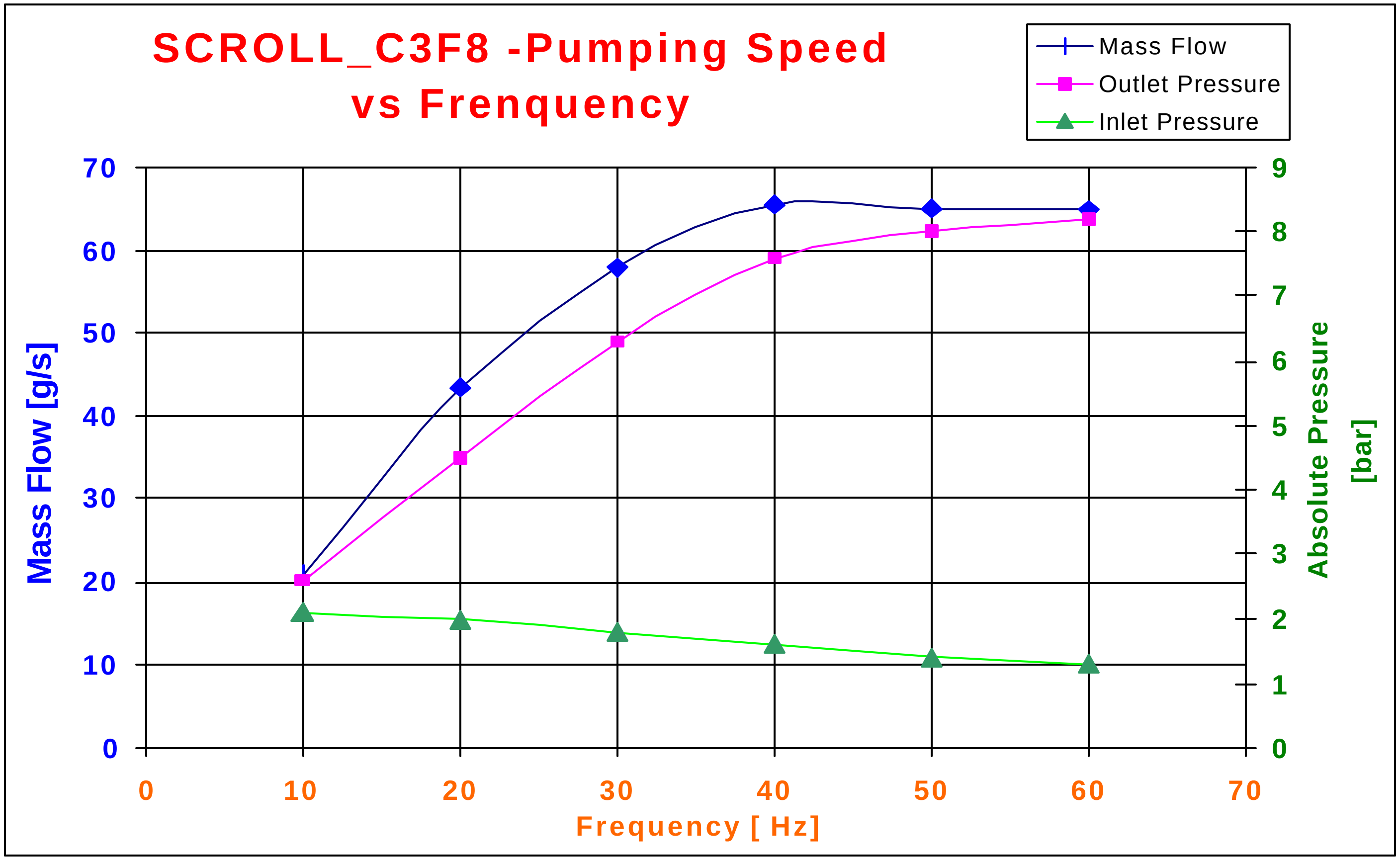
Setup for pumping speed measurement



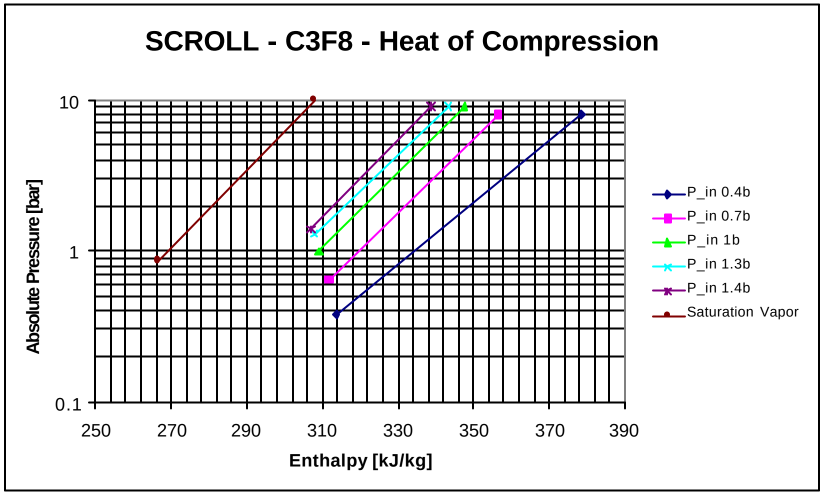
Pumping speed for the fundamental refrigerant vapors

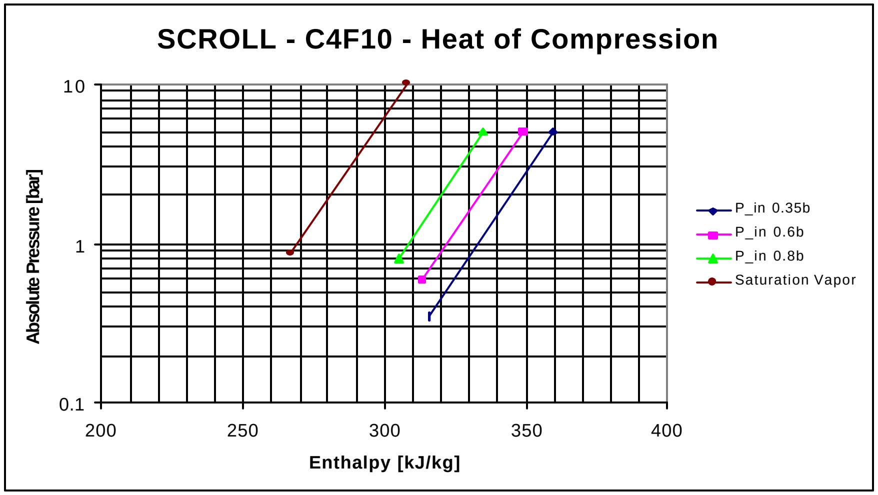


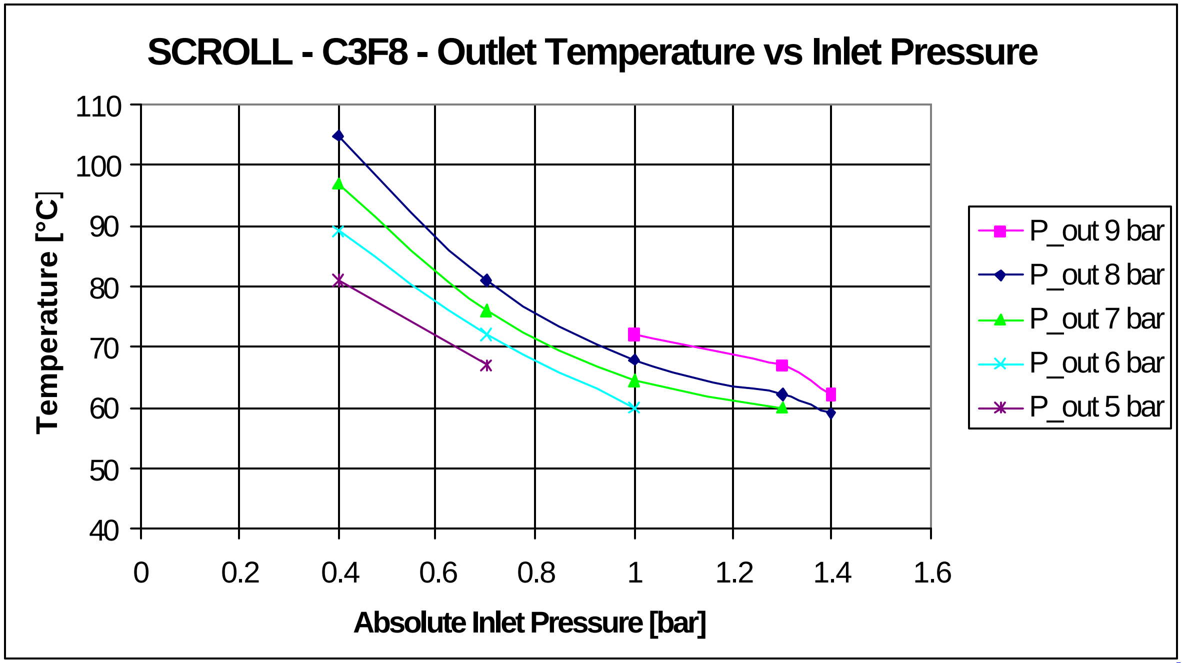
Performance variation for C_3F_8 with frequency change



Other characteristics







Conclusions

- Successful design changes and modification include:
  - Leak-tightness of the compressor box [Helium was used for the test]
  - Internal cooling loop implementation
  - Frequency regulator device implementation
  - Buffer tank modification
- Performance test have been done with following fluids:
  - Air [initial test]
  - Fluorinert vapors:
    - **C_4F_{10}**
    - **C_3F_8**

    [with an average measured flat pumping speed of ~20 m^3hr^{-1} for both C_4F_{10} (P_{in} = 0.25, P_{out} = 4 bar abs) and C_3F_8 (P_{in} = 1.4, P_{out} = 8 bar abs)].
- Scroll compressor is ready for an instalation into the main cooling system circuit and necessary workshop actions are under way.