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Vacuum Stability Around G-20 Gas Jet

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Subject(s) Vacuum Stability Around G-20 Gas Jet

Observations and Conclusions

Purpose

To search for a vacuum-stable operation mode for the gas jet experiment (E-778) at the G-20 straight section.

Setup and Procedure

The gas jet experiment at the G-20 straight section uses hydrogen and noble gas (Kr, Xe) mixtures as the target, which is formed by forcing high pressure gas (30 psi) through a small diameter (0.004") nozzle. A schematic of the vacuum components around the G-20 box is shown in Figure 1. Most (~ 80%) of this supersonic jet will be captured by the buffer volume and the remaining will be removed by the six diffusion pumps on the box or by the nearby ion pumps and turbomolecular pumps. Due to the large gas load during the pulsing of the gas jet and the need to protect the ring vacuum, two sector valves (G20 U/S and D/S), one turbostation (H3), as well as two cold cathode gauges (G17 and G20) are added in the GH superperiod. The G20 sector valves, which are interlocked by the cold cathode gauges, are also paralleled with the G13 and H3 valves which are interlocked by the ion pump current (at 1.5×10^{-5} Torr equivalent). The trip point of the cold cathode gauge at G17 is set at 1.5×10^{-5} Torr. The peak pressure at the G-20 box during jet pulsing is at 10^{-4} Torr level. Interlock at this level does not offer enough protection on the rest of ring vacuum. This is overcome by damping of the gauge controller and the trip point is set at 5×10^{-5} Torr.

To search for a vacuum-stable jet pulsing mode, we varied the pulsing width, the repetition time, the distance between the nozzle and the capture cone, and the pressure behind the nozzle. During the runs, the pressure distribution was monitored continuously through the ion pump current scan and the cold cathode gauge readings. Most of the tests were performed with the two turbos (G17 and H3) running and four ion pumps (G15, G16, G16, H3) operating. Some tests were done with two more (G18, H2) or four more (G18, G19, H1, H2) ion pumps operating. Until October 24, a slow solenoid was used to control pulsing which has opening and closing times of ~ 20 msec; since October 25, a fast solenoid with opening and closing times of ~ msec has been used. The nozzle with the fast solenoid has less throughput than that of the slow one.

The jet pulsing mode is classified as vacuum-unstable if the peak average pressure of the GH superperiod (as measured by ion pump current) is over 1×10^{-5} Torr or if the pressure is still rising after 30 minutes of pulsing.

Observations

The peak pressures at the GH superperiod together with the jet pulsing modes are summarized in Table I. The only vacuum-stable runs with the slow solenoid were those (#5, 6, 7) with 25 psi and 2.5 sec (SEB mode) repetition time. The gas load at GH was reduced by operating at 25 psi instead of at 30 psi. Further reduction to 20 psi caused the blowup of the jet profile (#9 versus #8 and 10). The capture efficiency of the buffer volume increased with the decreasing distance between the nozzle and the capture cone (#12 versus #13). Little difference in vacuum was observed between pure H_2 and H_2/1% Kr (#19 versus #17, 18). Pulsing widths of 75 ms (#14) and 100 ms were tested and terminated immediately due to pressure interlock. Attempts to operate the ion pumps near the G-20 box (G18, G19, G20, H1, H2) failed since the heating of pump elements and bodies generated more gas than they pumped (#18 versus #17). This is best illustrated by Figure 2, the peak pressure 10 feet away from the box (G19, H1) is as high as 7×10^{-5} which is beyond the limit of the stable operation pressure of the ion pump. The average pressures of G, GH, and H before and during the pulsing are also shown in Figure 2 as a comparison. By gating the G20 gauge output, vacuum recovery time (width between 10% of peak) of ~ 350 msec for pulsing width of 50 msec was measured.

Conclusions

1. Vacuum-stable operating conditions around the G-20 gas jet experiment do exist as summarized in Table I.

2. Due to the high peak pressure (see Figure 2 for pressure distribution), no ion pumps should be operated within 20 feet of the G-20 box.

3. A pulsing width of longer than 50 msec might be possible if the distance between the nozzle and the capture cone is 2-1/2". Additional turbos at G19 and H1 certainly will help.

4. The effect of H_2/10% Kr, Xe target to the ion pump operation needs to be studied (pumping speed of ion pump for Kr, Xe is only 1% of that for air).

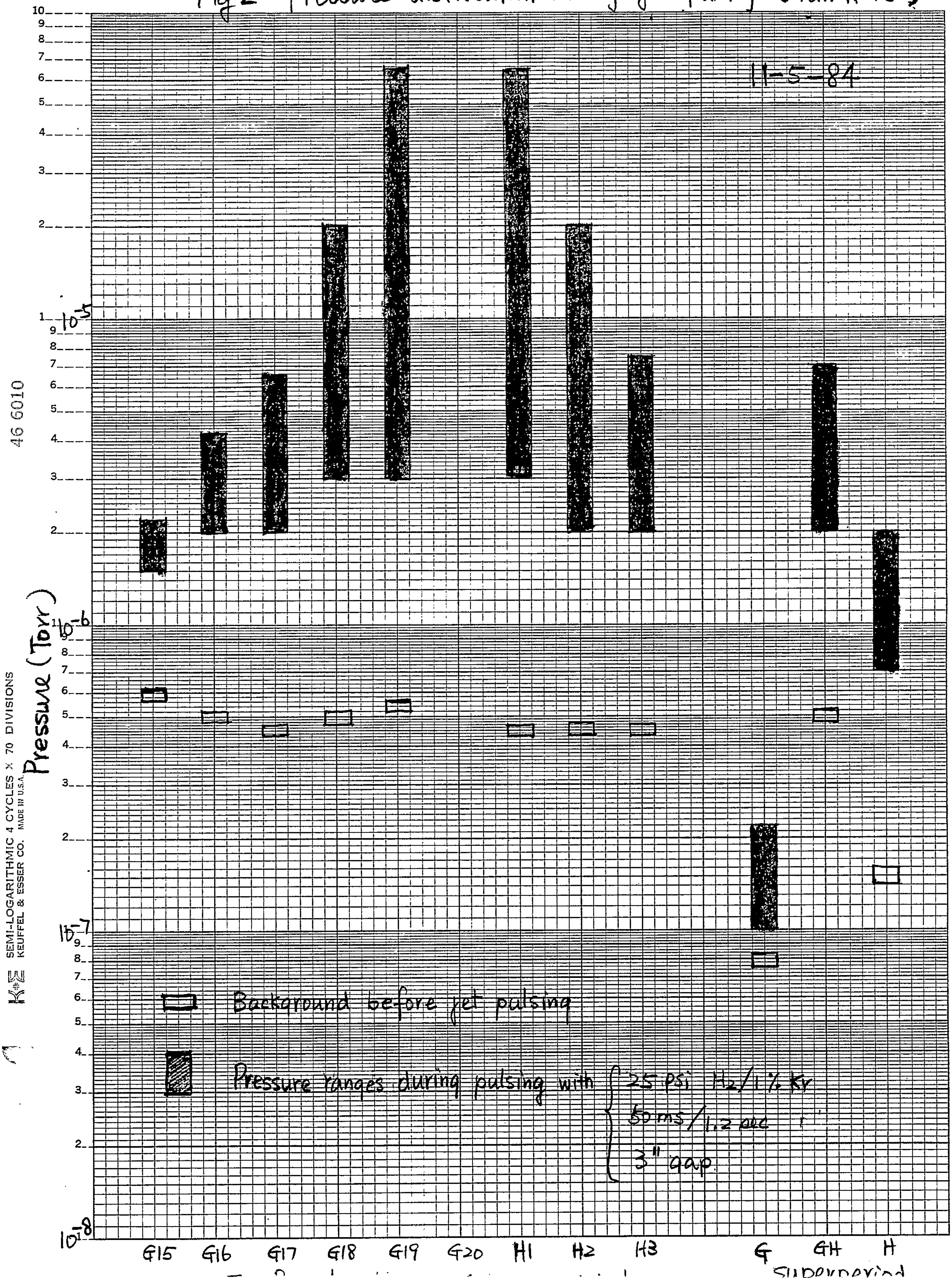
Table I

Vacuum Stability at Different Jet Pulsing Modes

Run #	Date	d(inches)	P(psi)	dt/Δt(ms/s)	t(min)	$\bar{P}_{max}$(Torr)	I(mA)/#IP	Remarks
1	10/22	3	30	50/2.5	20	1.3-5	200/6	N
2	10/24	3	30	50/2.5	10	9-6	68/4	N
3	"	2-3/4	30	50/2.5	10	1-5	90/4	N
4	"	2-1/2	30	50/2.5	14	1.2-5	110/4	N
5	"	2-1/2	25	50/2.5	66	8-6	52/4	Y
6	"	2-3/4	25	50/2.5	70	8-6	58/4	Y
7	"	3	25	50/2.5	55	9-6	62/4	Y
8	"	2-1/2	25	50/1.2	15	1-5	92/4	N
9	"	2-1/2	20	50/1.2	25	1.3-5	130/4	N
10	"	2-1/2	25	50/1.2	60	1.2-5	110/4	N
11**	10/25*	3	30	50/2.5	30	7-6	44/4	Y
12**	"	2-3/4	30	50/1.2	35	8-6	61/4	Y
13	"	3	30	50/1.2	50	1-5	85/4	Y
14	"	3	30	75/1.2	2	2-5	~300/4	N
15	10/29	3	30	50/1.2	35	6-6	42/4	Y
16	10/31	3	30	50/1.2	35	1.2-5	160/4	N
17**	10/31	3	25	50/1.2	330	6-6	45/4	Y
18	11/5	3	25	50/1.2	25	---	300/8	N
19**	11/5	3	25	50/1.2	160	6-6	40/4	Y 1% Kr

*	A fast solenoid valve has been used to pulse jet nozzle since 10/25/84.
d	Distance between jet nozzle and capture cone.
P	Hydrogen gas pressure behind the 0.004" nozzle (note run #19 was H_2/1% Kr).
dt/Δt	Jet pulsing width (ms) versus repetition time (sec).
t	Length of study before failure or termination.
$\bar{P}_{max}$	Peak pressure of GH superperiod at end of run as measured by ion pump current.
I/#IP	Total peak current of # operating ion pumps in GH superperiod at end of each run.
Y	Indicates stable vacuum.
N	Indicates rising pressure at end of runs.
**	Suggested pulsing mode.

Fig 2 Pressure distribution during jet pulsing (run #18)



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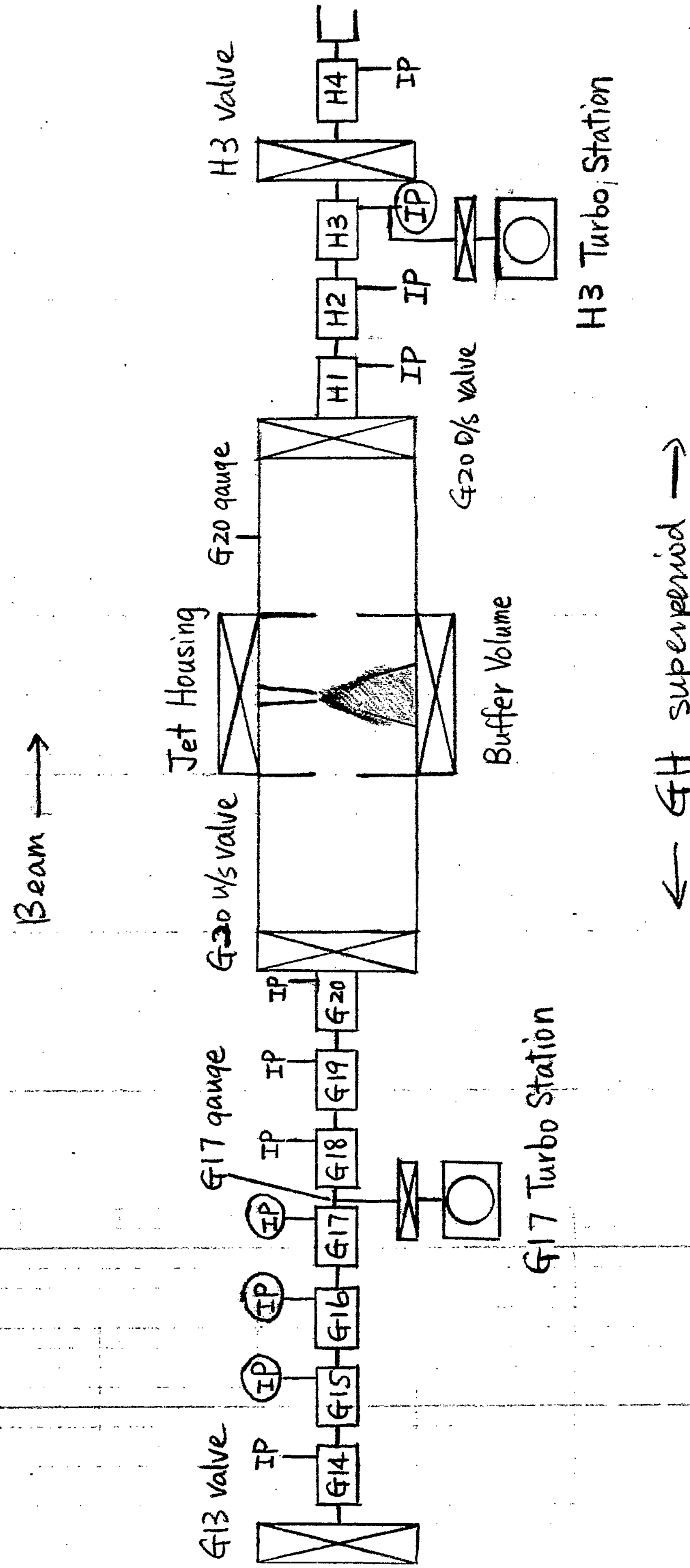

Fig. 1 Vacuum Components in GH Superperiod