

Emergency Gas Transfer

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Abstract

Normally two branches of Xe and CO₂ correspondingly serve for the gas transfer in Box-S. In case one of the branches is invalidated, the other one should be enabled to transfer both of the gases to continue the mixing process. That's why the emergency tubing and valves of V20a and V20b are built between V1a and V1b. They will lead Xe to the CO₂ branch or lead CO₂ to Xe branch either way.

The trial experiment has been done in Rome. The procedure of transferring both of Xe and CO₂ through either Xe branch or CO₂ branch is discussed in this write up.

1. Main Problems

There are two main problems in transferring both of the gases in one branch.

1. How to deal with the residual gas in the buffers when we switch to transfer another gas.
2. since the buffer volume of Xe branch is almost 3 times of that of CO₂ branch, the amount of CO₂ transferred through Xe branch may be too much.

For the first problem, when we switch to transfer another gas, the proportion of CO₂ in mixing gas measured by partial pressure could be affected by the residual gas in buffer. One way is to vent out the residual gas. That's the easiest way, but we need to add more valves which will increase the complexity of electrical control. Another way is to open all the valves between buffers and Vessel D. Then we not only transfer most of the residual gas to the Vessel D, but also know the pressure in buffer which is the same as the pressure in Vessel D. We can easily calculate how much residual gas is still in the buffers.

For the second problem, since CO₂ is not ideal gas, we try to do the experiment to show how much CO₂ could be transferred in one shot through Xe branch.

2. Experiment

The trial experiment is separated into two parts, transferring CO₂ through the Xe branch and transferring Xe through the CO₂ branch. Since we only have Ar bottle, we will use Ar instead of Xe in this trial experiment.

The procedure of transferring Ar through CO₂ branch

1. Transfer of CO₂

- (1) Do normal CO₂ transfer cycles. (V1b 2s, V2b 2s and V3b 40s)
- (2) Open V2b and V3b simultaneously for 60s
- (3) Record the pressure of Vessel D and temperature of buffers

2. Transfer of Ar

- (1) Open V1a, V20a and V20b simultaneously for 3s
- (2) Open V2b 2s and then V3b 40s
- (3) Repeat step (1) and step (2)

3. Measure the residual Ar in buffers

- (1) Open V2b and V3b simultaneously for 60s
- (2) Record the pressure of Vessel D and temperature of buffers.

Experiment Data

Temperature of Vessel D: 21.19⁰C

Initial Pressure	CO ₂ 1 cycle	V2b&V3b 60s	V1a,V20a&V20b 3s	V2b 2s->V3b 40s
15.08	24.42	29.70	29.70	31.70

Table 1. Pressure of Vessel D (psia)

The procedure of transferring CO₂ through Xe branch

1. Transfer of Ar

- (1) Do normal Ar transfer cycles. (V1a 2s, V2a 2s and V3a 20s)
- (2) Open V2a and V3a simultaneously for 60s
- (3) Record the pressure of Vessel D and temperature of buffers

2. Transfer of CO₂

- (1) Open V1b, V20a and V20b simultaneously for 3s
- (2) Open V2a 2s and then V3a 40s
- (3) Repeat step (1) and step (2)

3. Measure the residual CO₂ in buffers

- (1) Open V2a and V3a simultaneously for 60s
- (2) Record the pressure of Vessel D and temperature of buffers.

Experiment Data

Temperature of Vessel D: 21.50°C

Initial Pressure	Ar 1 cycle	V2a&V3a 60s	V1b,V20a&V20b 3s	V2a 2s->V3a 40s	V2a&V3a 60s
15.08	25.90	29.36	29.36	43.38	47.85

Table 2. Pressure of Vessel D (psia)

3. Conclusion

During the trial experiment, all the valves function well. We realized the transfer of CO₂ through Xe branch and transfer of Ar through CO₂ branch.

The CO₂ transfer through Xe branch is about 14 psi for one shot. It's not too bigger than the amount through its own branch which is about 10 psi. So the CO₂ transfer through Xe branch is controllable. That may be because the CO₂ bottle is half empty. The density is about 3.89mol/l at that time. The experiment to test the transfer when the gas bottle is full needs to be done in future.

When we open V2 and V3 simultaneously, the increasing amount of CO₂ is less than 60% of the amount by one shot. This amount should be considered ahead, otherwise we will transfer too much gas for mixing.

Since the spirometer could not work at that time, the cross check of the ratio should be done in future.