ALPS Heat Transfer: Li Flow Experiment

Conference at Grand Canyon *April 10-11, 2003*

presentations:

LIMITS: Magnet Model and Preparation	**Mike Ulrickson**
LIMITS: Li Flow Experiment	**Jimmie McDonald**
LIMITS: Flow Meter Calibration	**Richard Nygren**
LIMITS: Future Plans	**Mike Ulrickson**

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EM Flow Meter Calibration

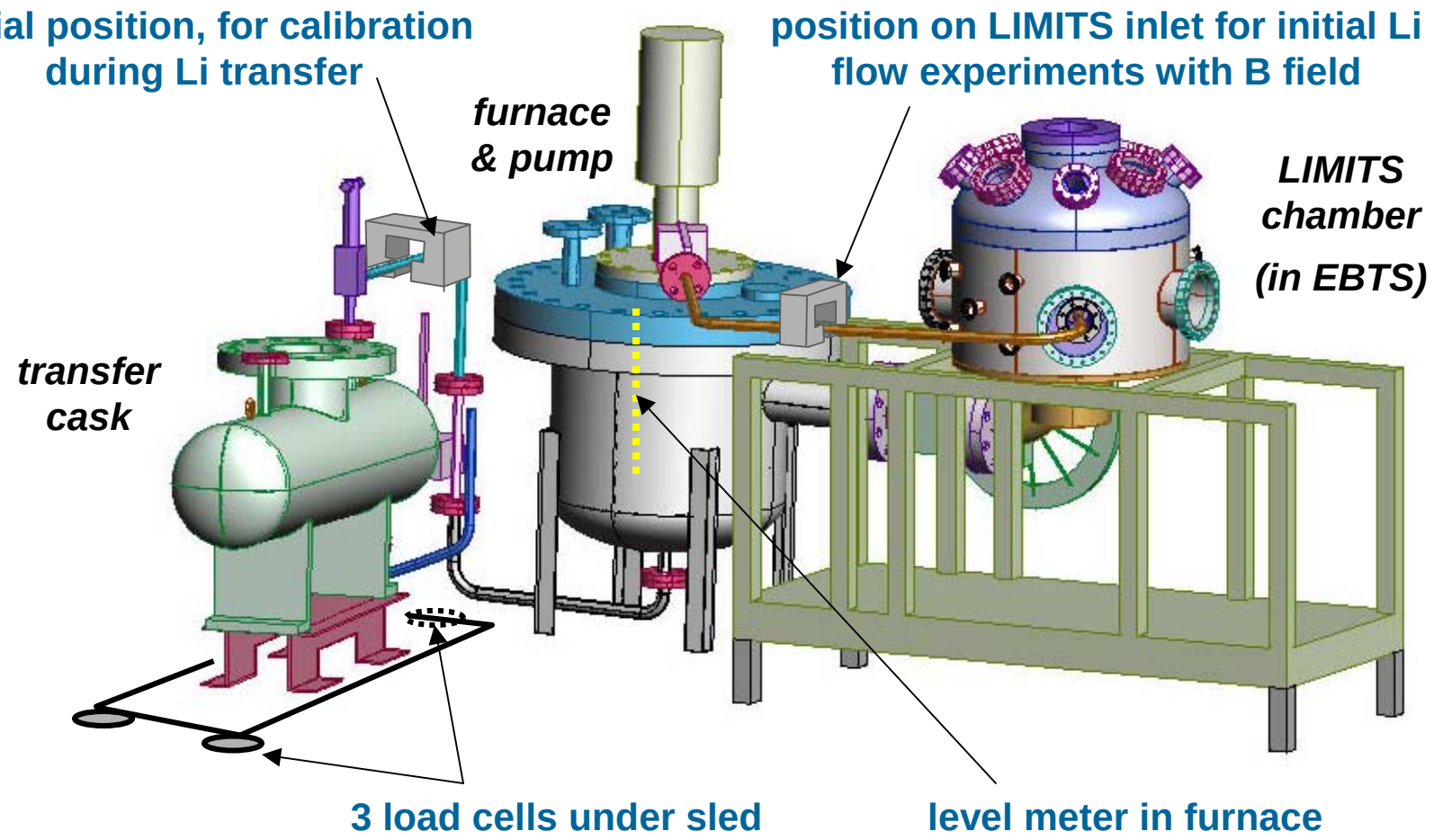
Preparation:

- Flow meter model
- Yoke design and purchase
- Yoke assembly, magnets attached
- Field map with 3-D Hall probe
- Preparation of LIMITS (***McDonald/Tanaka/Ulrikson, Session 19***)

Calibration:

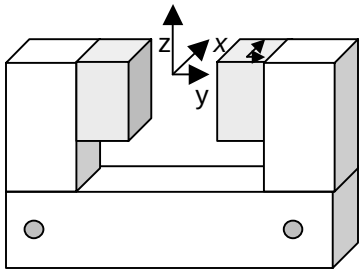
- Li transfers (3) between transfer cask and furnace
- Data for Li flow meter, weight change (load cells) and level meter in furnace
- Data analysis and calibration results

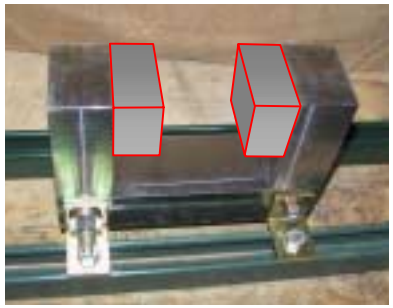
EM flow meter on LIMITS

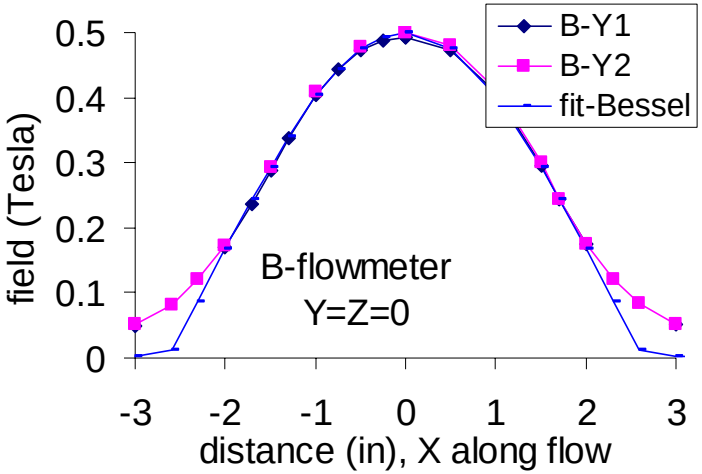


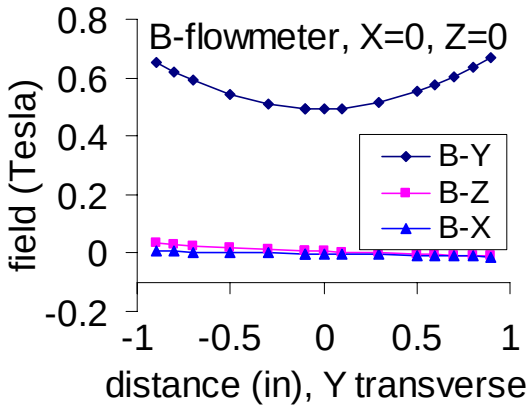
We first mapped the magnetic field of the flow meter.

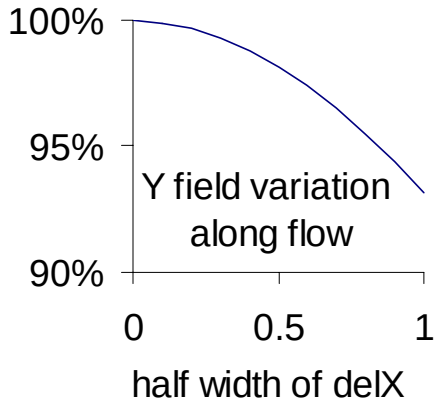
- 3-D Hall probe
- assembled flow meter mounted on mill bed





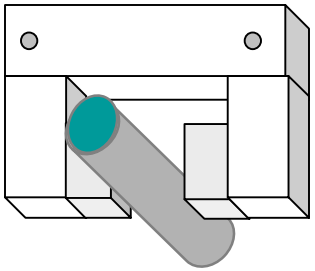






Initial calibrations were during transfer of Li to the furnace.

- **Flow meter (inverted) was installed on the 1” SS tube (0.82” ID) between the transfer cask and the furnace.**
- **We did 3 transfers by changing the Argon gas pressures in the cask and furnace.**



T1. Li from cask to furnace.

T2. Li from furnace to cask with flow meter raised 3/8” from T1.

T3. Li from furnace to cask with flow meter 3/8”below T1.

Transfer procedure

1. Purge the transfer line (between valves) with low P Ar to ~2psi
2. Existing pressure in transfer cask was ~25psi and was bled down to ~8psi
3. Verify all temps are above 180°C
4. Turn off pumping to furnace
5. Isolate LIMITS
6. Pressurizing furnace to P ref
7. Bleed transfer cask to P-ref
8. Start data logger (2Hz) XFR_01.dat
9. Closed furnace valve
10. Open 1" ball valve, then open bellow valve
11. Open gas line (bellows valve) to transfer tank
12. Slowly increase P in transfer tank until transfer begins
13. Adjust pressure to continue flow
14. When transfer is completed; close Ar gas feed; close bellows valve
15. Stop data logger, save file XFR_01.dat

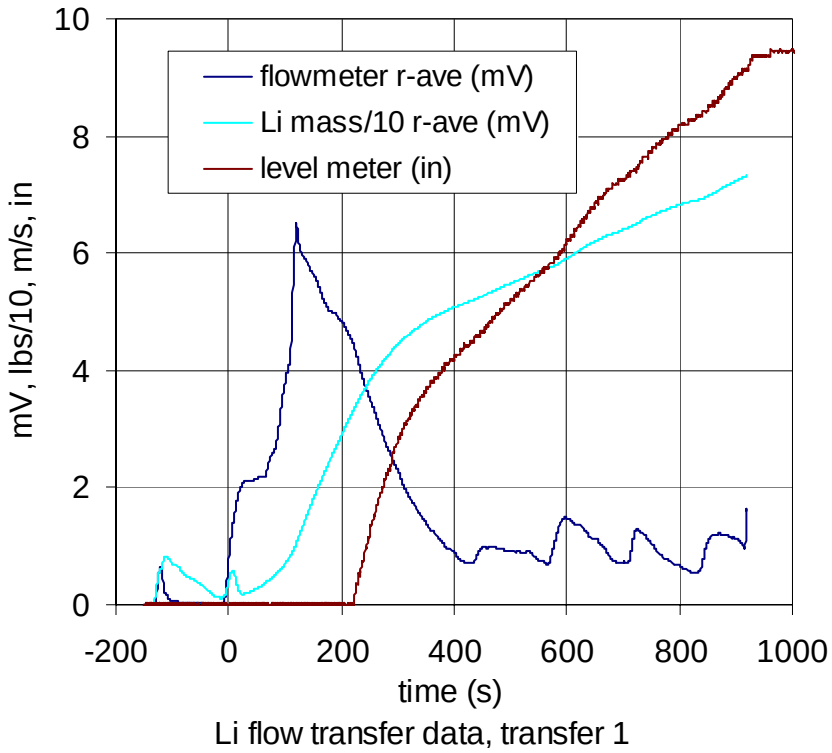
We monitored three signals for calibration.

The primary objective was a calibration factor (K), which when multiplied with the flow meter signal, gives the flow in meters per second through the 0.82"ID SS tube.

We monitored three signals:

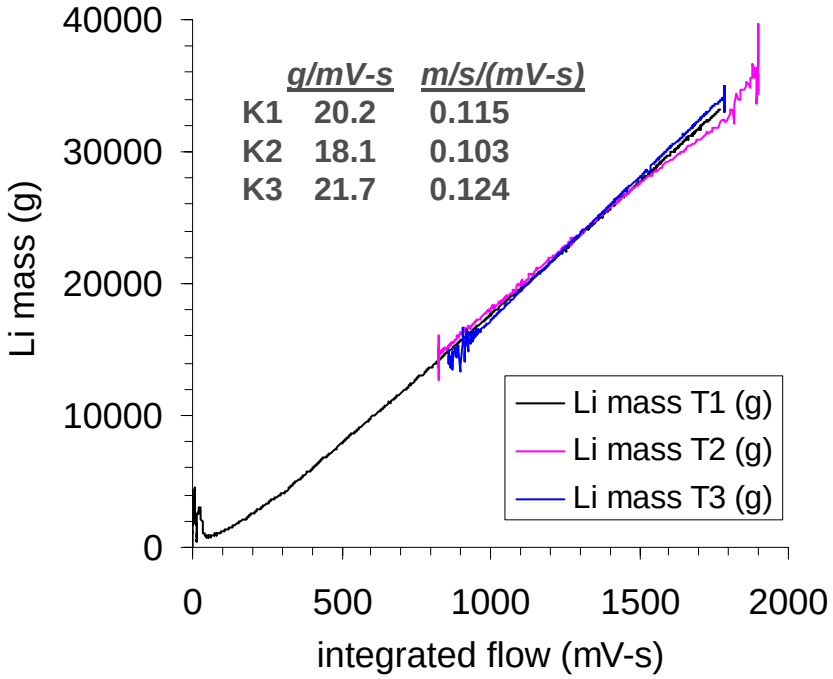
1. **weight of transfer cask**
2. **fill level in the furnace**
3. **flow meter (few millivolts)**

plus many thermocouples on the heating system for the furnace, cask and piping.



Li flow transfer data, transfer 1

Integrated flow versus mass gives a basic calibration.



Master curve (per Tom Lutz) shows integrated flow (mV-s) plotted against the Li weight.

Integration constants (offsets) for T 2 and T3 were set to overlay the curves.

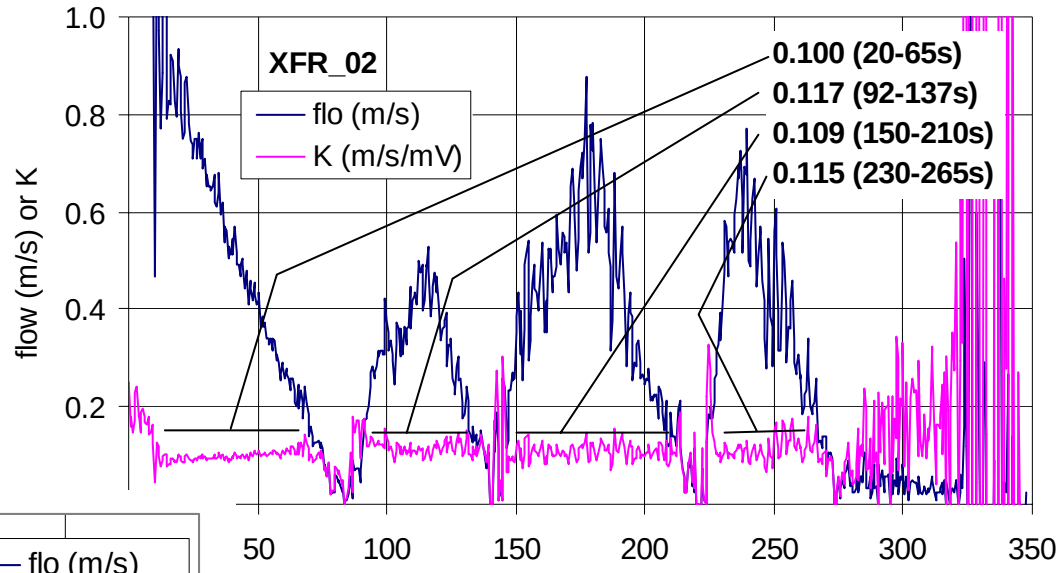
The slope, in g/(mV-s), was converted for K in (m/s)/mV by dividing by the density (0.515g/cm^3), flow area (3.407cm^2) and 100cm/m.

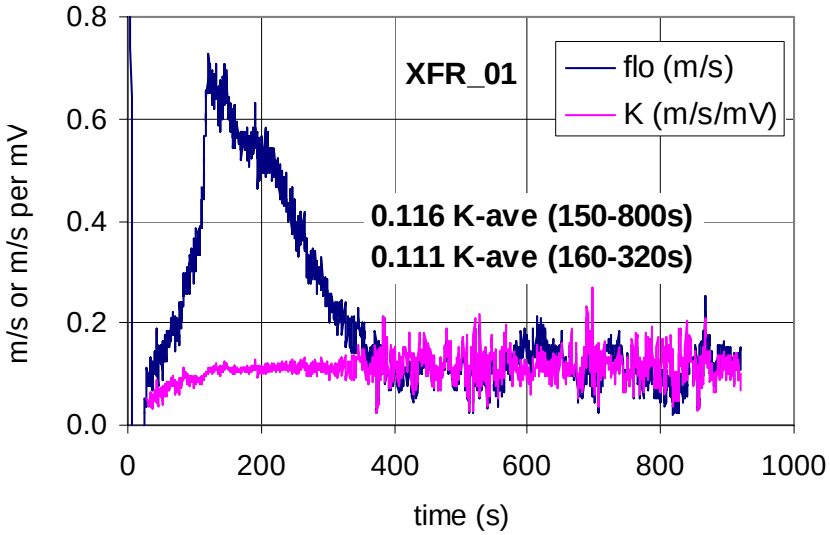
Differing values for K were expected because the position of the flow meter was changed.

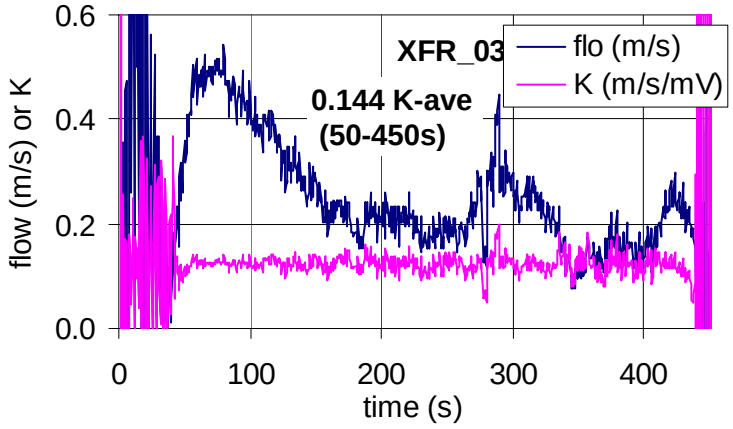
Time-dependent details in the signals were evaluated.

"Flo" curves are based on the derivative of weight change (20-point running average). K curves are instantaneous ratios of "flo" to the flow meter signal.

K-ave for T3, with pipe in lower B field, was higher than for T1 and T2.

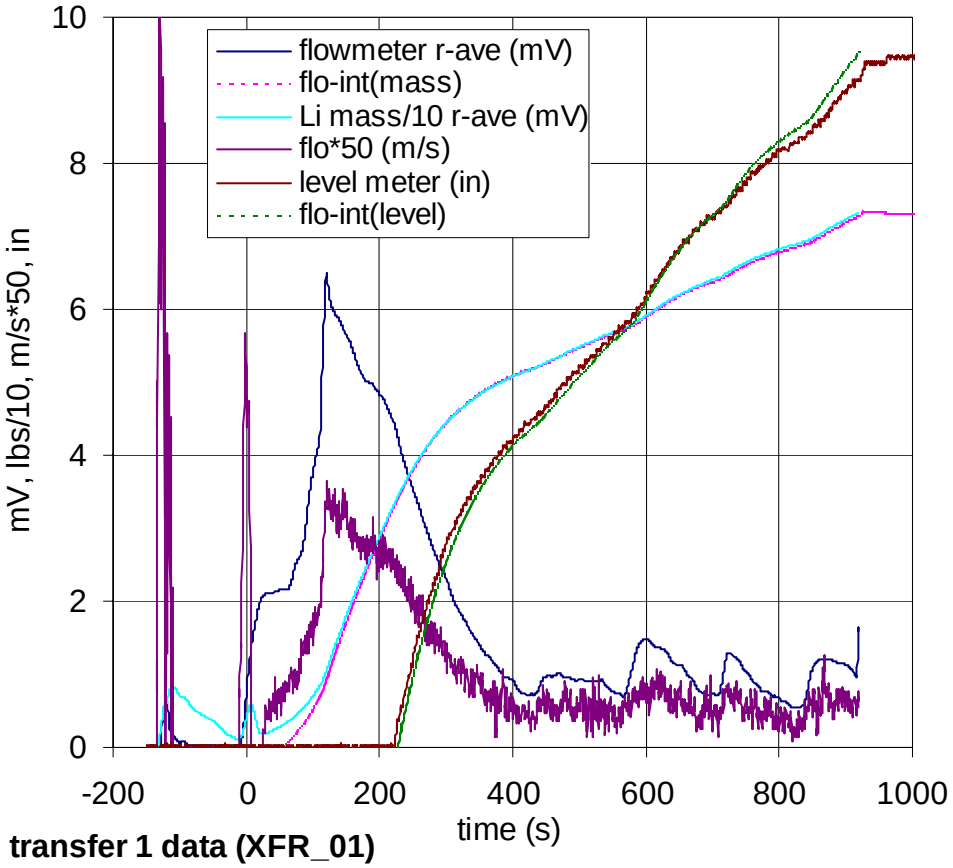






Li mass and level meter curves were reconstructed.

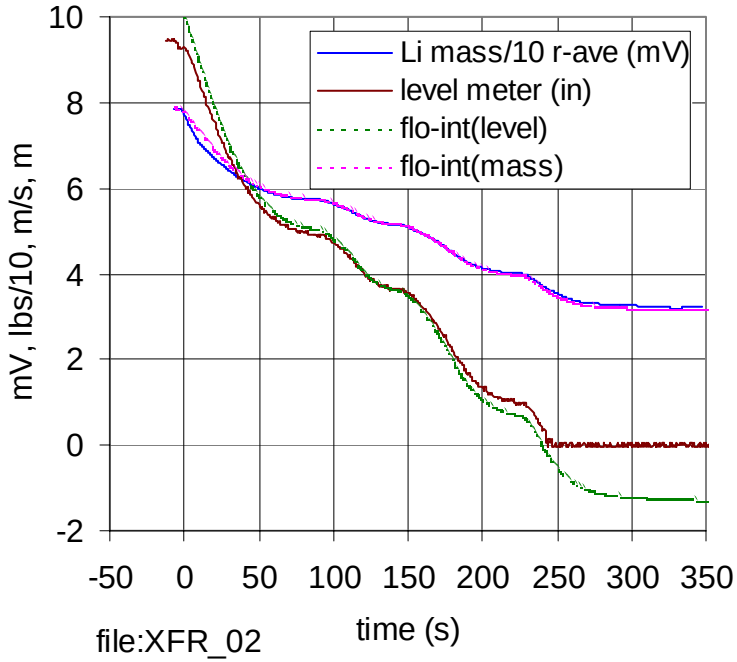
- The **flo-int$_{mass}$** and **flo-int$_{level}$** curves are the integrated flow meter signal multiplied by fitting constants.
- The good agreement shows a general consistency between the mass transfer, level meter (previously uncalibrated) and the flow meter.

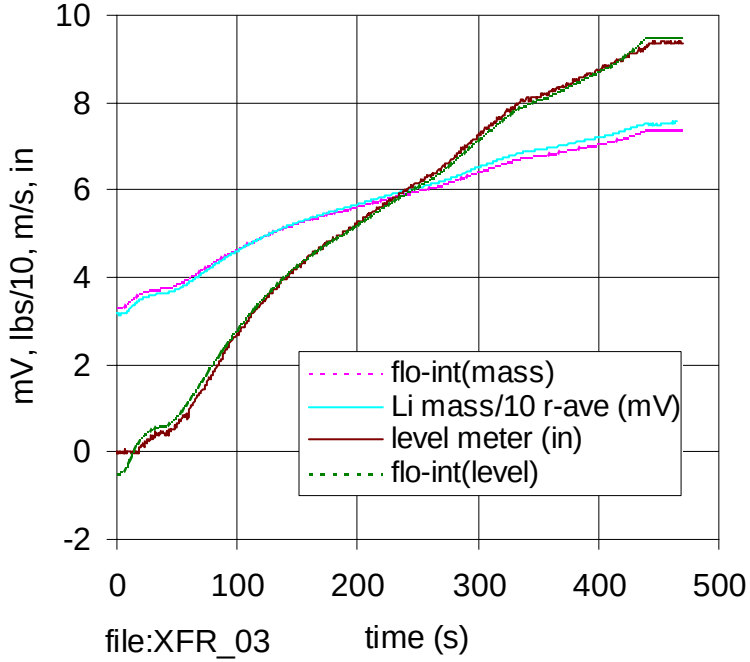


transfer 1 data (XFR_01)

Li mass and level meter curves were reconstructed.

- **Essentially perfect fits could be obtained using separate fitting constants for each curve.**
- **The cases shown use the same fitting constant for all three transfers.**





Concluding Comments

Note on Li flow test in LIMITS

In a short measurement with the flow meter on LIMITS, signal oscillations were excessive.

We believe vibrations of the pipe (observed) when the valve was opened rapidly caused the oscillations.

- **The flow meter works well!**
- **Our diagnostics work well. We got good agreement between the mass transfer, previously uncalibrated level meter and the flow meter.**
- **We will calibrate the flow meter with the pump for a given plumbing/nozzle configuration for Li flow tests.**