Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: LITER Characterization and ELM Mitigation		
OP-XP-827	Revision: **0**	Effective Date: **5/5/08** Expiration Date: **5/5/10** *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: H. Kugel	Date
ATI – ET Group Leader: V. Soukhanovskii	Date
RLM - Run Coordinator: M. Bell	Date
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: **LITER Characterization and ELM Mitigation** No. **OP-XP-827**

AUTHOR: **H. Kugel** DATE: **4/30/08**

1. Overview of planned experiment

This XP will characterize 2 LITER operation and ELM mitigation with increasing lithium deposition rate and total deposition. Figure 1 shows the experimental sequence to determine effect of deposition rate and one- and two-LITER coverage on ELMs and density.

Figures 2 and 3 show the reference discharges. Figure 4 shows the simulated evaporation rate. Tables 1 and 2 shall be used to record the shot numbers. Table 3 shows the evaporation rate versus temperature. Table 4 shows LITER control times and shutter and vessel accumulation.

2. Theoretical/ empirical justification

TFTR, CDX-U/LTX, and NSTX demonstrated the ability of lithium to control density.

3. Experimental run plan

3.1 The Preliminary Test Procedure (PTP) shall bake LITER-Bay F and LITER-Bay K in their respective Garage spools with the TIV closed for at least 48 hours at 150° C. During this time the respective units shall be operated at 220°C for 1 hour to outgas absorbed gases (e.g. air, and Ar).

3.2 The Integrated System Test Procedure (ISTP) shall be performed by inserting both LITER units into NSTX to their Parked Positions. Close the Shutters. With the shutters closed, raise the operating temperature of each unit to deliver an evaporation rate of about 1 mg/min (510°C) for 1 minute, as fast as machine vacuum conditions will allow. Then the LITER power shall be shut off using the LITER computer programmed sequence.

3.3 On the morning of XP-827, insert the two LITER units to their Parked Positions with the Shutters closed. Raise their operating temperatures to 400°.

3.4 Before introduction of lithium, establish the Day-1 and Day-2 baseline conditions. First perform up to 3 reference discharges for Day-2 (128026). Repeat if necessary until at least 2 reproducible shots are obtained. Then perform up to 3 reference discharges for Day-1(125269 at 4 MW). Repeat Keep fueling the same. Repeat if necessary until at least 2 reproducible shots are obtained.

a) Option-A: The Day-1 reference is 125269 at 4 MW instead of the original 6 MW.

b) Option-B: If desirable, the Day-1 reference is 125269 at the original 6 MW (this may be a possible end of day test).

c) Option-C: The backup reference shot is 127889 with Bt =0.45 T.

3.5 If H-mode and ELMs are obtained reliably in the Day-1 reference discharges (125269) proceed with the LITER lithium deposition rate sequence illustrated in Fig.1. Record the shot numbers and associated data in Tables 1 and 2.

3.6 On Day-2, perform up to 3 Day-1 reference discharges. Repeat if necessary until at least 2 reproducible shots are obtained to document the effect of overnight conditions on the occurrence of ELMS.

3.7 Then perform 3 Day-2 reference discharges (128026). Repeat if necessary until at least 2 reproducible shots are obtained. The proceed with the LITER lithium deposition rate sequence illustrated in Fig.1. Record the shot numbers and associated data in Table 2. Following Day-2, prior to switching over to the next XP, conduct 2-3 reference shots to assess residual lithium effects.

3.8 Proceed with steps 3.4-3.6 until locked modes prevent suitable discharges, or the H-mode low density limit is reached, or as determined by experimenters from review of diagnostic data.

a) If locked modes start to occur increase LFS gas in steps of 10 Tl/s.

b) If H-mode density threshold problems occur increase SGI gas in 200 Torr steps and adjust timing as required.

c) Choose best experimental conditions for maintaining a flat density waveform. Use density normalized to fueling as a figure of merit.

d) If necessary, or time allows, apply optimized EFC to suppress adverse MHD and/or locked modes if they appear as density is reduced and/or change edge conditions.

4. Required machine, NBI, RF, CHI and diagnostic capabilities

On Day-1, D LSND H-mode shot 125269 with 3 NBI (Day-1) and on Day-2, D LSND H-mode shot 128026 with 3 NBI. HeGDC during LITER operation as outlined in Tables 1 and 2.

5. Planned analysis

UEDGE, TRANSP, etc.

6. Planned publication of results

PSI08, POP, Nucl. Fusion, IAEA08

Table 1. XP-827 Day-1 Experimental Sequence

Day-1 Reference Discharge = 125269 (Fig.2)

XP827 Shot No.	LITER-F g/min	LITER-K g/min	Total Lithium (g) For 10 min Depositions	HeGDC (min)
Day-2 ref 128026	0	0	0	5
Day-2 ref 128026	0	0	0	5
Day-2 ref 128026	0	0	0	5
Day-1 ref 125269	0	0	0	5
Day-1 ref 125269	0	0	0	5
Day-1 ref 125269	0	0	0	5
1				5
2				5
3				5
4				5
5				5
6				5
7				5
8				5
9				5
10				5
11				5
12				5
13				5
14				5
15				5
16				5
17				5
18				5
19				5
20				5
21				5
22				5
23				5
24				5
25				5

Table 2. XP-827 Day-2 Experimental Sequence

Day-2 Reference Discharge = 128026 (Fig.3)

XP826 Shot No.	LITER-F g/min	LITER-K g/min	Total Lithium (g) For 10 min Depositions	HeGDC (min)
Day-1 ref 125269	0	0	0	5
Day-1 ref 125269	0	0	0	5
Day-1 ref 125269	0	0	0	5
Day-2 ref 128026	0	0	0	5
Day-2 ref 128026	0	0	0	5
Day-2 ref 128026	0	0	0	5
26				5
27				5
28				5
29				4
30				4
31				3
32				3
33				2
34				2
35				1
36				1
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				

PHYSICS OPERATIONS REQUEST

Title**:** LITER Characterization and ELM Mitigation **OP-XP-827**

Machine conditions: <u>Day-1</u>: 128026 Reference, 125269 Reference (@4MW), and 125269 Operation (@4 MW)

<u>Day-2</u>: 1282026 Reference, and 128026 Operation

I_{TF} (kA): **-53** Flattop start/stop (s): **-0.01/1.1**

I_P (MA): **0.8-0.9 MA** Flattop start/stop (s): **0.2/1.0**

Configuration: **LSN**

Outer gap (m): Inner gap (m):

Elongation κ: Triangularity δ:

Z position (m):

Gas Species: **D** Injector(s): **CS mid, OM #2**

NBI - Species: **D** Sources: **A, B, C** Voltage (kV): **90** Duration (s): **0.8**

ICRF – Power (MW): Phasing: Duration (s):

CHI:

Either: List previous shot numbers for setup **125269 and 128026 with 3 NBI**

Or: Sketch the desired time profiles, including inner and outer gaps, κ, δ, heating, fuelling, etc. as appropriate. Accurately label the sketch with times and values.

DIAGNOSTIC CHECKLIST

TITLE: XP-827 No. **OP-XP-827**

AUTHORS: H. Kugel DATE: 4/30/08

Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Bolometer – tangential array	√	
Bolometer – divertor	√	
CHERS – toroidal	√	
CHERS – poloidal	√	
Divertor fast camera	√	
Dust detector	√	
EBW radiometers		
Edge deposition monitors	√	
Edge neutral density diag.	√	
Edge pressure gauges	√	
Edge rotation diagnostic	√	
Fast ion D_alpha - FIDA		√
Fast lost ion probes - IFLIP		√
Fast lost ion probes - SFLIP		√
Filterscopes	√	
FIReTIP	√	
Gas puff imaging		√
Hα camera - 1D	√	
High-k scattering	√	
Infrared cameras	√	
Interferometer - 1 mm	√	
Langmuir probes – divertor	√	
Langmuir probes – BEaP		√
Langmuir probes – RF ant.		√
Magnetics – Diamagnetism	√	
Magnetics – Flux loops	√	
Magnetics – Locked modes	√	
Magnetics – Pickup coils	√	
Magnetics – Rogowski coils	√	
Magnetics – Halo currents	√	
Magnetics – RWM sensors	√	
Mirnov coils – high f.	√	
Mirnov coils – poloidal array	√	
Mirnov coils – toroidal array	√	
Mirnov coils – 3-axis proto.	√	

Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
MSE	√	
NPA – ExB scanning		
NPA – solid state		
Neutron measurements	√	
Plasma TV	√	
Reciprocating probe		
Reflectometer – 65GHz	√	
Reflectometer – correlation	√	
Reflectometer – FM/CW	√	
Reflectometer – fixed f	√	
Reflectometer – SOL	√	
RF edge probes		
Spectrometer – SPRED	√	
Spectrometer – VIPS	√	
SWIFT – 2D flow	√	
Thomson scattering	√	
Ultrasoft X-ray arrays	√	
Ultrasoft X-rays – bicolor	√	
Ultrasoft X-rays – TG spectr.	√	
Visible bremsstrahlung det.	√	
X-ray crystal spectrom. - H		
X-ray crystal spectrom. - V		
X-ray fast pinhole camera		
X-ray spectrometer - XEUS	√	

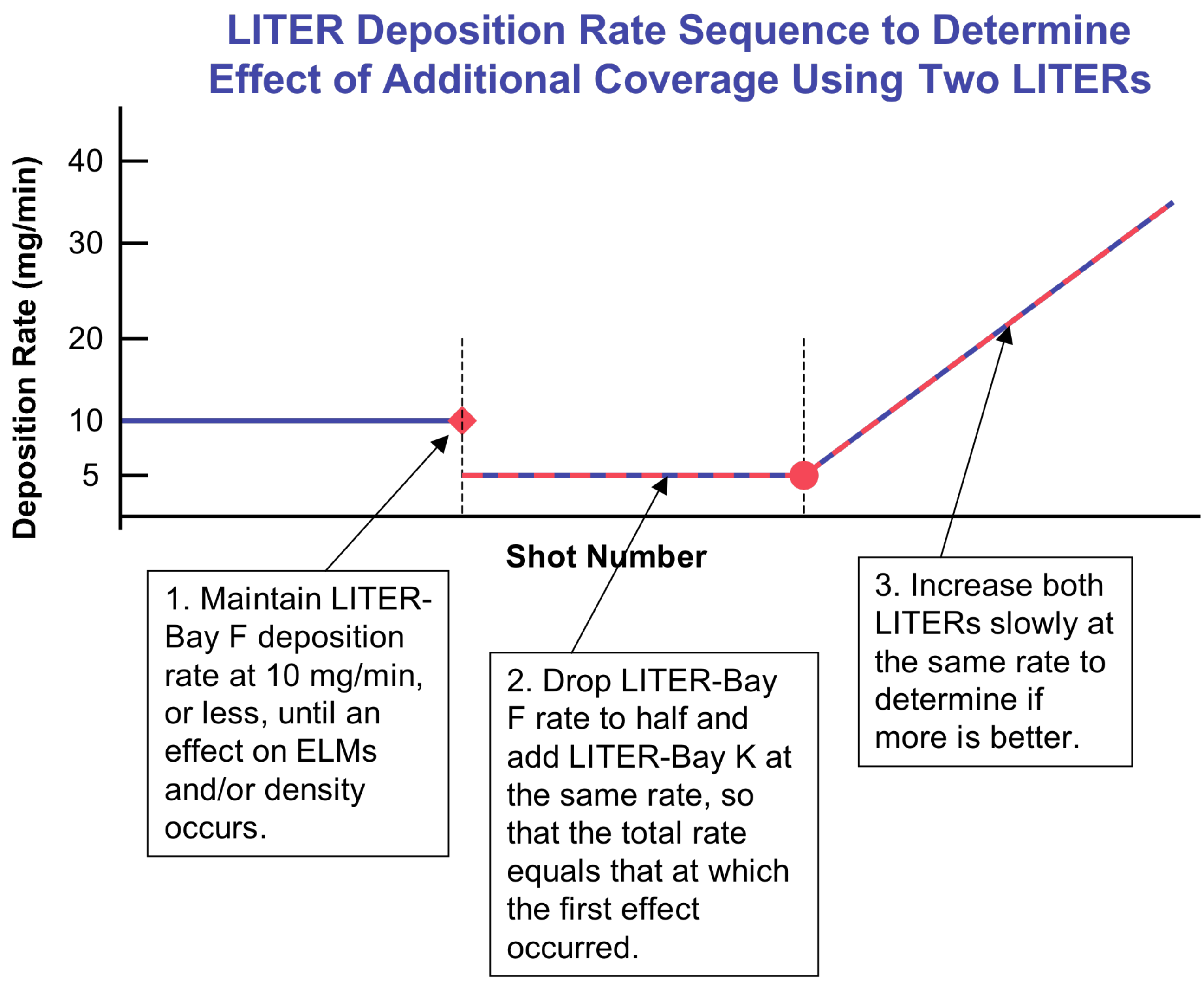
LITER Deposition Rate Sequence to Determine
Effect of Additional Coverage Using Two LITERs
Deposition Rate (mg/min)
40
30
20
10
5
Shot Number
1. Maintain LITER-Bay F deposition rate at 10 mg/min, or less, until an effect on ELMs and/or density occurs.
2. Drop LITER-Bay F rate to half and add LITER-Bay K at the same rate, so that the total rate equals that at which the first effect occurred.
3. Increase both LITERs slowly at the same rate to determine if more is better.

Fig. 1

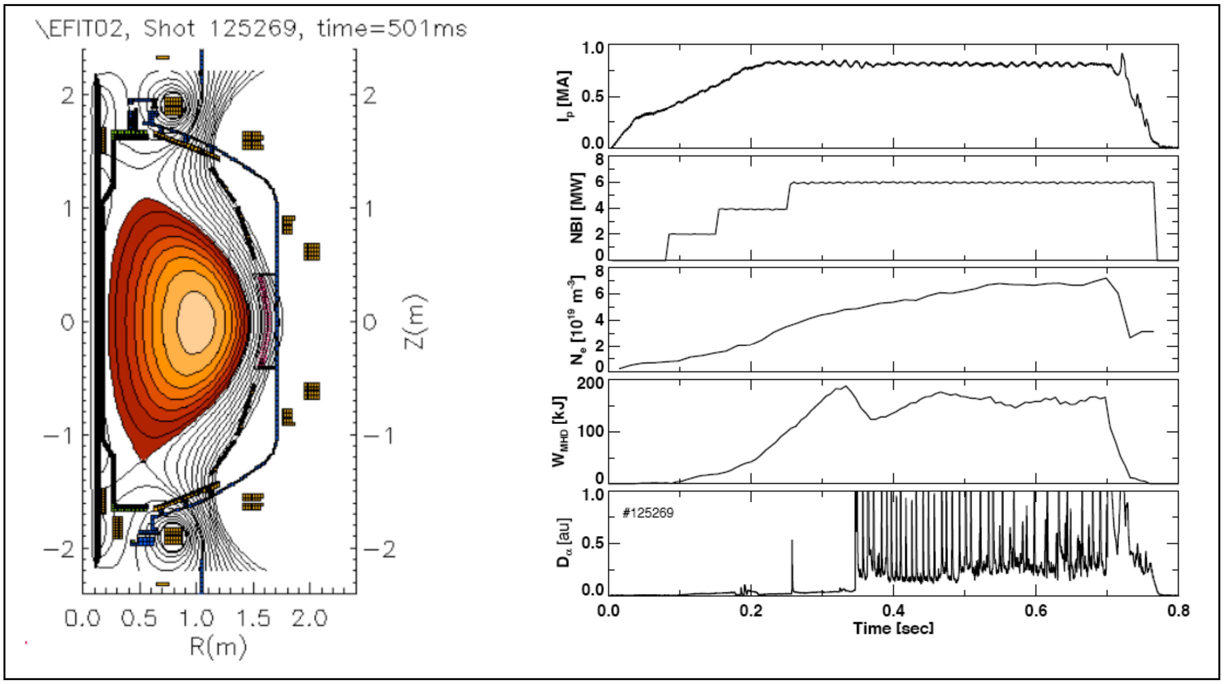

Fig.2 Reference discharge 125269 for Day-1.

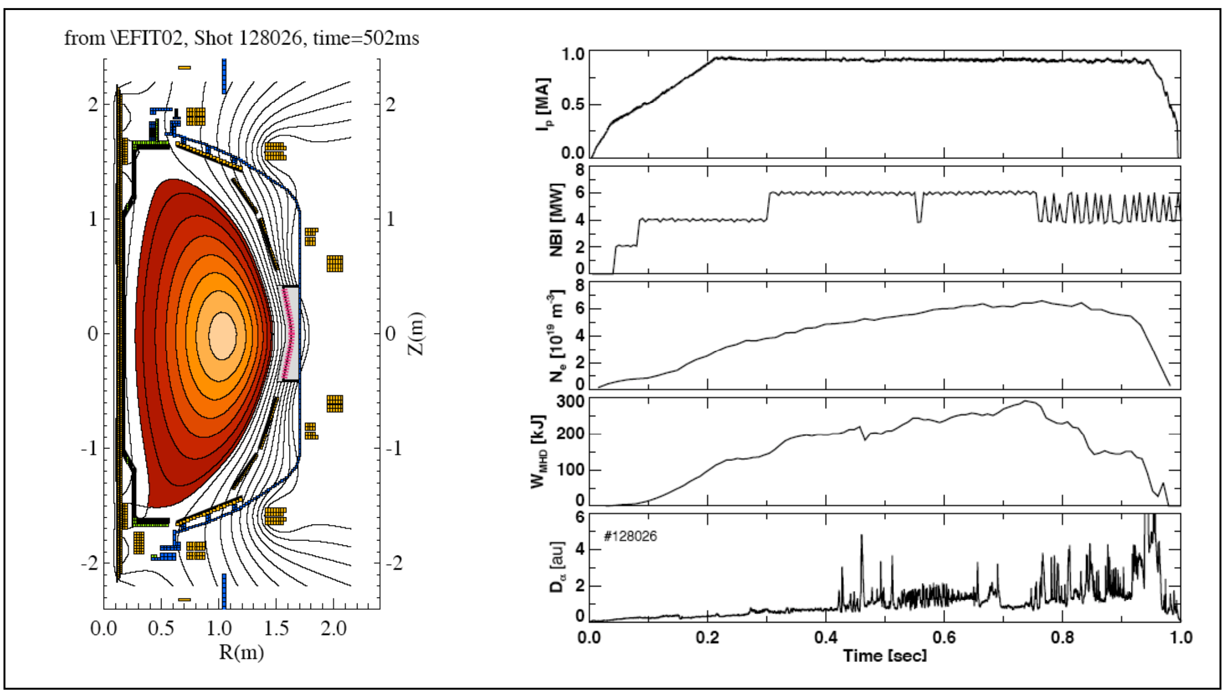

Fig.3 Reference discharge 128026 for Day-2.

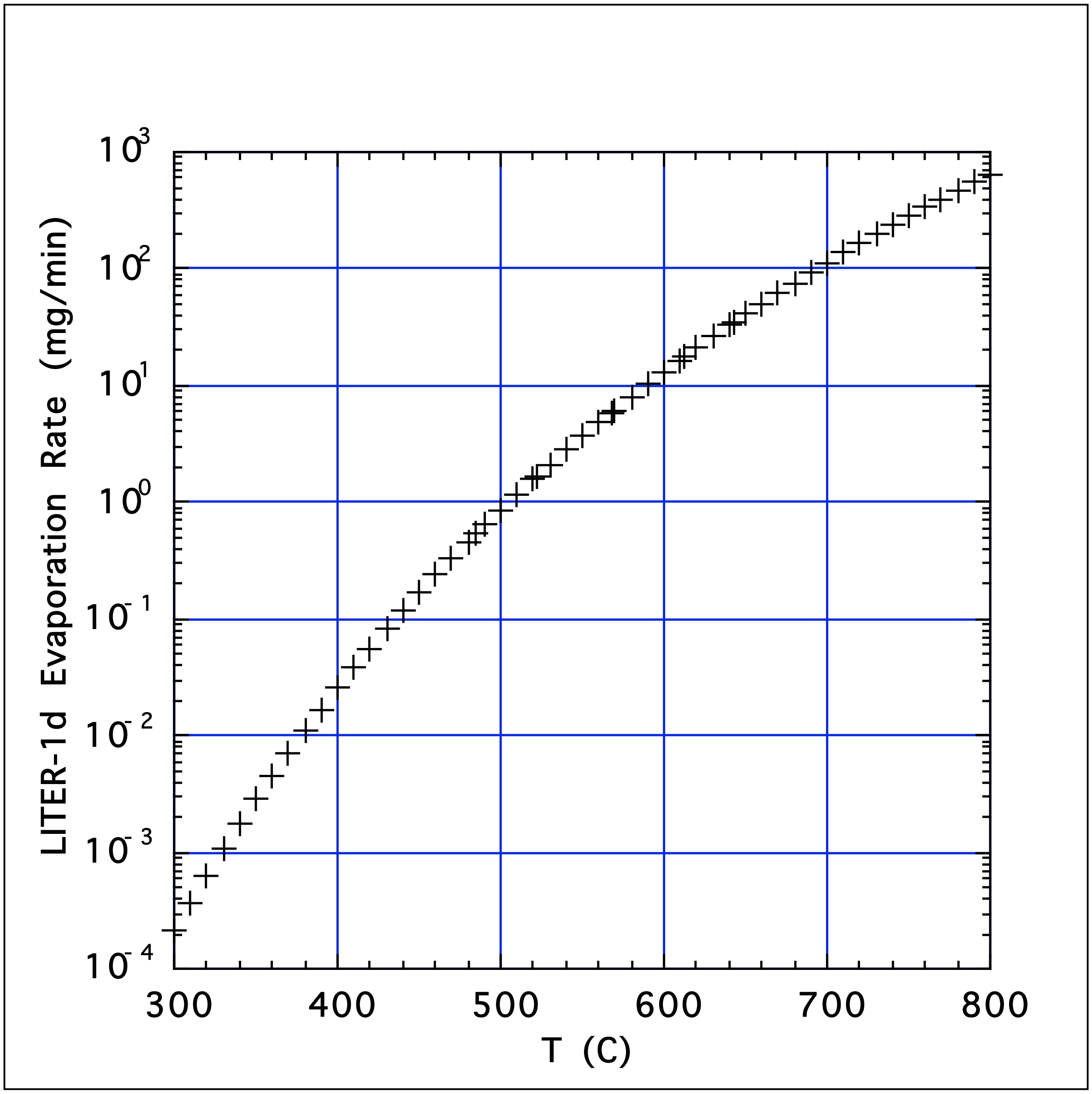

Fig.4 LITER-1d simulated evaporation rate (mg/min) versus temperature (°C) for atomic vapor flow. Evaporation rate enhancement is expected above 650° due to viscous flow effects

TABLE 3. LITER-1d evaporation rate

T (C)	Rate (mg/min)
300.00	2.12853e-04
310.00	3.69784e-04
320.00	6.30473e-04
330.00	1.05594e-03
340.00	1.73881e-03
350.00	2.81742e-03
360.00	4.49550e-03
370.00	7.06870e-03
380.00	1.09605e-02
390.00	1.67698e-02
400.00	2.53330e-02
410.00	3.78055e-02
420.00	5.57648e-02
430.00	8.13430e-02
440.00	1.17392e-01
450.00	1.67690e-01
460.00	2.37199e-01
470.00	3.32371e-01
480.00	4.61535e-01
485.30	5.47310e-01
490.00	6.35349e-01
500.00	8.67346e-01
510.00	1.17458e+00
520.00	1.57841e+00
522.20	1.68274e+00
530.00	2.10536e+00
540.00	2.78819e+00
550.00	3.66710e+00
560.00	4.79109e+00
568.20	5.93694e+00
570.00	6.21957e+00
580.00	8.02416e+00
590.00	1.02907e+01
600.00	1.31217e+01
610.00	1.66385e+01
613.20	1.79315e+01
620.00	2.09846e+01
630.00	2.63287e+01
640.00	3.28681e+01
643.20	3.52497e+01
650.00	4.08325e+01
660.00	5.04885e+01
670.00	6.21440e+01
680.00	7.61535e+01
690.00	9.29229e+01
700.00	1.12916e+02
710.00	1.36661e+02
720.00	1.64757e+02
730.00	1.97880e+02
740.00	2.36792e+02
750.00	2.82354e+02

Table 4.

LITER CONTROL TIMES

Start retraction	T-60 toT-50s
Retraction from Op to Pk	14s (7inch @0.5inch/s)
Shutter close	T-15s
If no GDC, insert starts	T+6s
Shutter opens	T+4s
Shutter closed	T-15 to +4s

No HeGDC, Shutter Closed=20s & Total Deposition Time into Vessel = 10min						
Dep Rate		Shutter	Vessel	Total shutter	Total vessel	Total Li
(mg/min)		mg/shot	mg/shot	mg/25 shots	mg/25 shots	mg/25 shots
1		0.33	10	8.3	250	258.3
10		3.33	100	83.3	2500	2583.3
15		5.00	150	125.0	3750	3875.0
20		6.67	200	166.7	5000	5166.7
25		8.33	250	208.3	6250	6458.3
30		10.00	300	250.0	7500	7750.0
35		11.67	350	291.7	8750	9041.7
40		13.33	400	333.3	10000	10333.3
45		15.00	450	375.0	11250	11625.0
50		16.67	500	416.7	12500	12916.7

5 min HeGDC, Shutter Closed=20s +5min, & Total Deposition Time into Vessel per 10 min						
Dep Rate		Shutter	Vessel	Total shutter	Total vessel	Total Li
(mg/min)		mg/shot	mg/shot	mg/25 shots	mg/25 shots	mg/25 shots
1		5.33	10	133.3	250	383.3
10		53.33	100	1333.3	2500	3833.3
15		80.00	150	2000.0	3750	5750.0
20		106.67	200	2666.7	5000	7666.7
25		133.33	250	3333.3	6250	9583.3
30		160.00	300	4000.0	7500	11500.0
35		186.67	350	4666.7	8750	13416.7
40		213.33	400	5333.3	10000	15333.3
45		240.00	450	6000.0	11250	17250.0
50		266.67	500	6666.7	12500	19166.7