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SEB Extraction Study III - Measurement of Extraction Efficiency During the Spill

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Subject SEB Extraction Study III - Measurement of Extraction Efficiency during the Spill.

Observations and Conclusion

We have attempted to measure the extraction efficiency at the middle of spill as well as for the whole extraction period in order to separate the non-conventional beam losses (i.e., non-resonant beam components) at the beginning and the end of spill, which account for 30 to 40% of the total extraction beam loss. The total extraction efficiency is measured to be 97 to 98%, slightly higher than previous measurements (95 to 96%), and the middle extraction efficiency, giving close to 99% although the quality of the data prohibited making any quantitive measurements.

Introduction

This SEB Study III is part of the Extraction Group's continuous effort[1,2] to understand the current AGS SEB third interger resonance extraction process and to measure the extraction efficiency as accurate as possible for the present SEB extraction system with a W/Re(25)-wire septum at H20[3,4].

I. Setup

The following three IAGPE files were created and run simultaneously to collect extraction data at various times during the spill:

IAGPE Files

Parameters	1H20A	1H20B	2H20C
MAGPL	x	x	x
H20US/DS	x		
F05US/DS	x		
F10US/DS	x		
SESLD	x		
SSLNG	x		
RXL15 (=XCBM)		a	b/c
CE010 (=SEC)		d	b/c
RLMS		d	b/c
H20LS		d	
F5ULM/DLM		d	
F10UL/DL		d	

(a,b,c,d: data at T = 650, 1150, 1950 and 2150 msec, (respectively)

@ Transition : 255 ms   RF - Off : 665 ms
T-invert : 2150 ms   XCBM(650) : 4•10••12 ppp

II. Data Taking

Within the limited available beam time (less than 2 hours), we could manage to collect quickly the extraction data varying F10US/DS, F05US/DS, H20US/DS, HPBLW, F5FLG (in/out), F10FLG, H20FLG, SSLNG, SESLD, etc. and saved them on disk for an off-line analysis later.

III. Results

Though we have not yet complete our full analysis of the whole data set due to some technical difficulties in data processing, most essential results are sown in the following figures:

A. Varying the H20DS with H20US = 1724 fixed:

For the whole extraction period (T = 650-2150 ms).

Fig. 1a : RLMn vs. SECn (Total),
1b : RLMn, SECn-7 vs. H20DS (Total),

where RLMn = RLM(2150)/XCBM(650),
SECn = SEC(2150)/XCBM(650).

A linear fit to the RLMn-SECn data gives

RLMn = 15.2 - 1.83*SECn,

which yeilds a SEC calibration of 8.31 counts/10^{10} extracted protons and a RLM calibration of 13.4 counts per 10^{10} protons lost. At the optimum position of H20DS = 2040 $\pm$ 10 as seen in Figure 1b, the extraction (in)efficiency is 98 $\pm$ 0.5 (2.0 $\pm$ 0.4)%.

In order to separate the beam losses at the beginning and the end of the spill we took the same data at the middle of the spill (T = 1150 -1950 ms),

Fig. 2a : dRLMns vs. dSECn (Middle),
2b : dRLMn, dSECn-7 vs. H20DS (Middle),
2c : XCBMs vs. Pulse #

where

dRLMn = [RLM(1950)-RLM(1150)]/[XCBM(1150)-XCBM(1950)],
dSECn = [SEC(1950)-SEC(1150)]/[XCBM(1150)-XCBM(1950)].

Ther are two distinctive sets of data that appeared, one clustered around dSECn = 7.8, another around 8.5, apparently depending on whether the spill process had already been completed at the time of t = 1950 ms or not. (We should have set this timing earlier, e.g. t = 1800 ms, to avoid pulse-to-pulse variation of the spill duration.) It should be noted that in contrast the dRLMn values are almost identical for both cases. This indicates that even if the spill process ended before t = 1950 ms for some pulses, the non-resonant beam components (a fraction of the beam not extracted, approximately 1.5%) may have survived inside the machine for a moment (or may have lost inside the catcher so that an extra beam loss due to the non-resonant components did not make any contribution to RLM readings at t = 1950 ms) though XCBM(RXL15) read no beam left at that time for some reason as seen in Figure 2c.

Since the data is not self consistent and data points are rather spread, it is not proper to make any definite conclusions from these results. However, if you discard the data around dSECn = 7.8, then it is clear that relative extraction (in) efficiency at the middle of spill is systematically higher than one for the whole extraction period, as expected;

Whole	Middle
SECn = 8.16	dSECn = 8.50
RLMn = 0.28	dRLMn = 0.18

at the optimum position.

The data points at the middle of the spill do not line up on the same calibration line in Figure 1a, shifting to the higher dSECn side. A hand drawn line to the data gives a similar (very rough) calibration,

$$dRLMn = 15.5 - 1.80 * dSECn$$

which yields 98.7 (1.2)% extraction (in)efficiency.

Various other SEB beam loss monitor responses are also shown in Figure 3.

Fig. 3 : RLMn, H20Ln, F5Ln & F10Ln vs. SECn (Total)

where H20Ln = H20LS(2150)/XCBM(650
F5Ln = (F5ULM(2150) + F5DLM(2150)/XCBM(650)
F10Ln = (F10UL(2150) + F10DL(215)/XCBM(650)

These data also give similar extraction (in)efficiency = 97.5 - 99 (2-1)%.

B. Varying F5US/DS and F10US/DS

The loss of monitor responses for beam losses inducted by varying F5 septum or F10 ejector positions are shown in the following figures:

Fig. 4 : RLMn, H20Ln, F5Ln & F10Ln vs. SECn(Total) varying F5US/DS

Fig. 5 : RLMn, H20Ln, F5Ln & F10Ln vs. SECn(Total) varying F10US/DS

As seen in these figures, F5LM is not sensitive to losses caused by F10US/DS and H20LM are not sensitive to both cases. Each monitor responded rather erratically pulse-to-pulse and displayed substantial amount of hysteresis for beam losses induced by its own extraction magnet displacements. RLMn gave the most smooth response for all cases.

Extraction (in)efficiency obtained from this data is consistent with one obtained by varying H20DS.

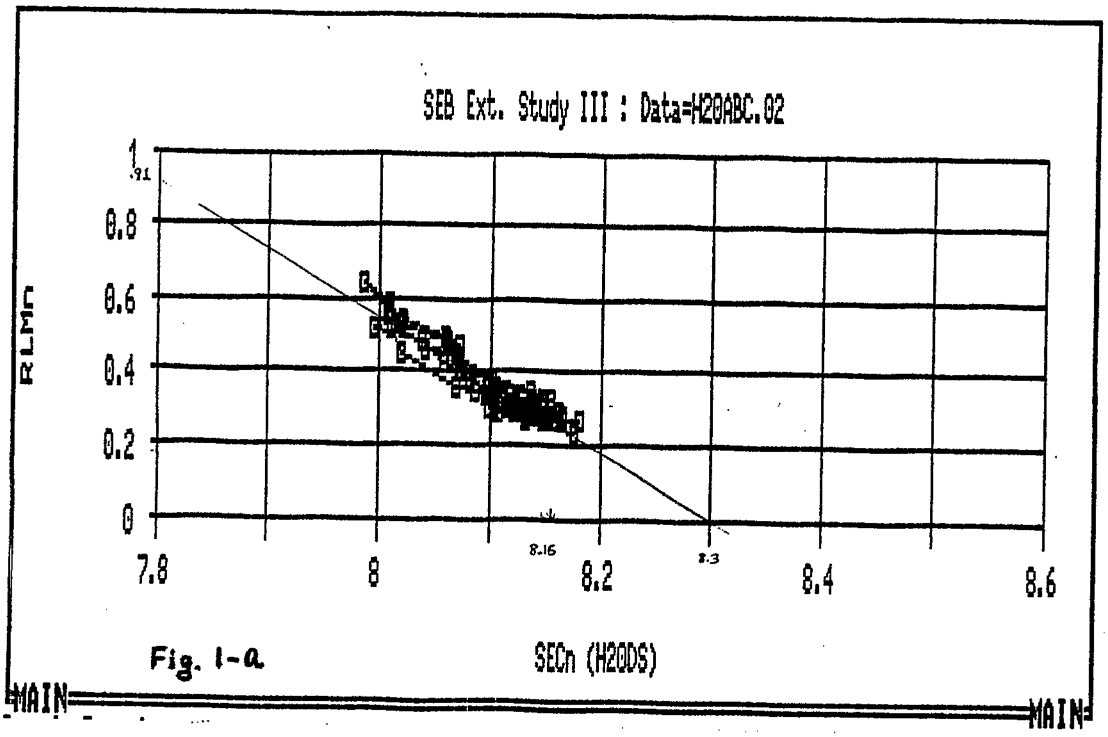
IV. Conclusions and Future Plans

To separate the beam loss at the beginning and the end of spill, which may account for more than one-third of the total beam loss during extraction, we attempted to measure simultaneously extraction efficiency at the middle of the spill. The total extraction efficiency is measured to be 97 to 98%, slightly higher than previous measurements (95 to 96%). The extraction efficiency at the middle of extraction is found to be systematically higher than the total extraction efficiency, giving close to 99%. The 1% middle inefficiency is believed to be the beam loss solely due to effects directly related to the H20 electrostatic septum. However, the quality of the data prohibited making any quantitative measurements.

For the next SEB extraction study (IV) in May, we plan to collect the same data with a hybrid Ti-alloy (low Z material) wire septum and do a full analysis of both data sets in order to see if there is any improvement in comparison with the present W/Re wire septum. In addition, technical difficulties we had in collecting, processing, and analyzing the data will be discussed in the next report.

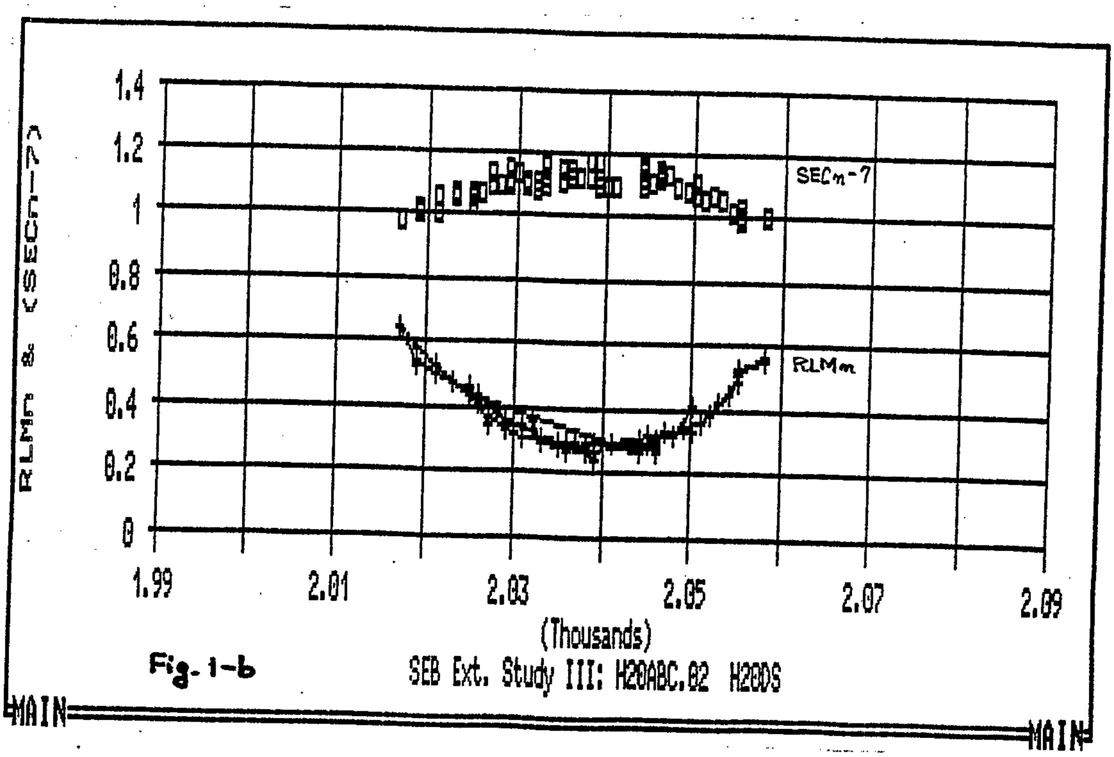
References

1. M. Tanaka, AGS Studies Report #219, "SEB Extraction Study I".
2. M. Tanaka, AGS Studies Report #222, "SEB Extraction Study II".
3. H. Weisberg and J.W. Glenn, Nucl. Instrum. & Meth. 169, 319 (1980), "Exploitation of Nonlinear Growth of Betatron Oscillations to Obtain Efficient Slow Extraction from the AGS".
4. M. Tanaka, Extraction Group Physics Note #0001, "The Electrostatic Wire Septum".



SEB Ext. Study III : Data=H20ABC.02
RLMn
1
.91
0.8
0.6
0.4
0.2
0
7.8
8
8.16
8.2
8.3
8.4
8.6
SECn (H20DS)
MAIN
MAIN

Fig. 1-a



RLMn & (SECn-7)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
SECn-7
RLMn
1.99
2.01
2.03
2.05
2.07
2.09
(Thousands)
SEB Ext. Study III: H20ABC.02 H20DS
MAIN
MAIN

Fig. 1-b

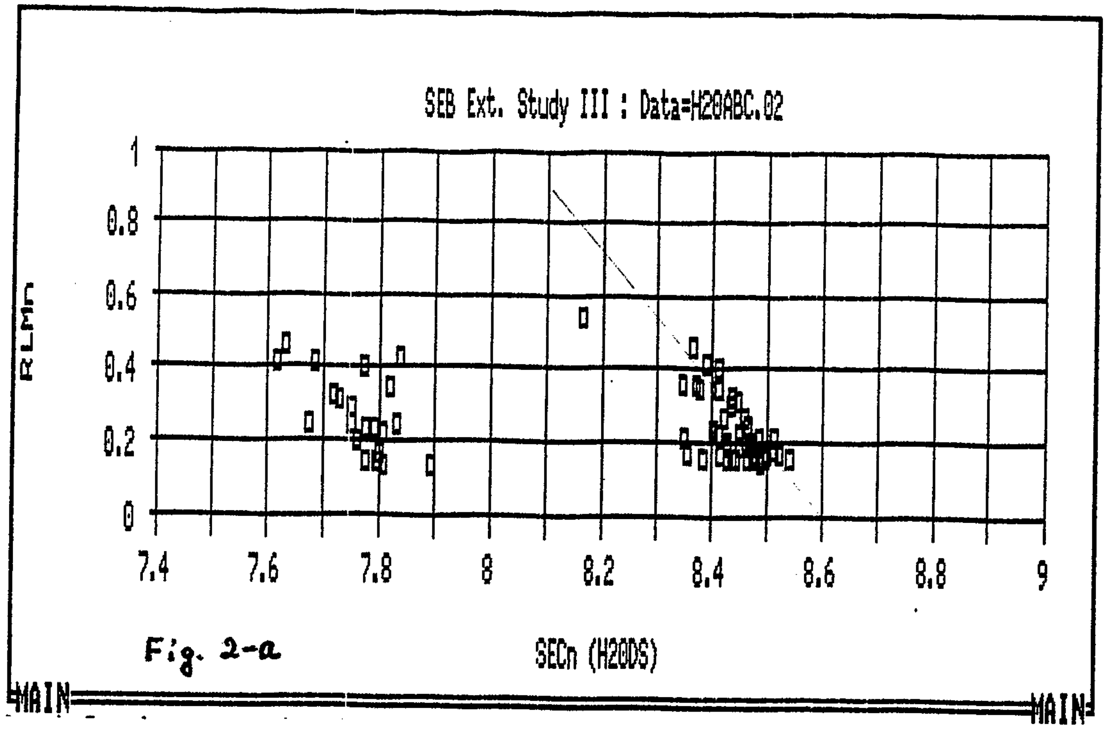

SEB Ext. Study III : Data=H20ABC.02
RLMn
SECn (H20DS)
1
0.8
0.6
0.4
0.2
0
7.4
7.6
7.8
8
8.2
8.4
8.6
8.8
9
MAIN
MAIN

Fig. 2-a

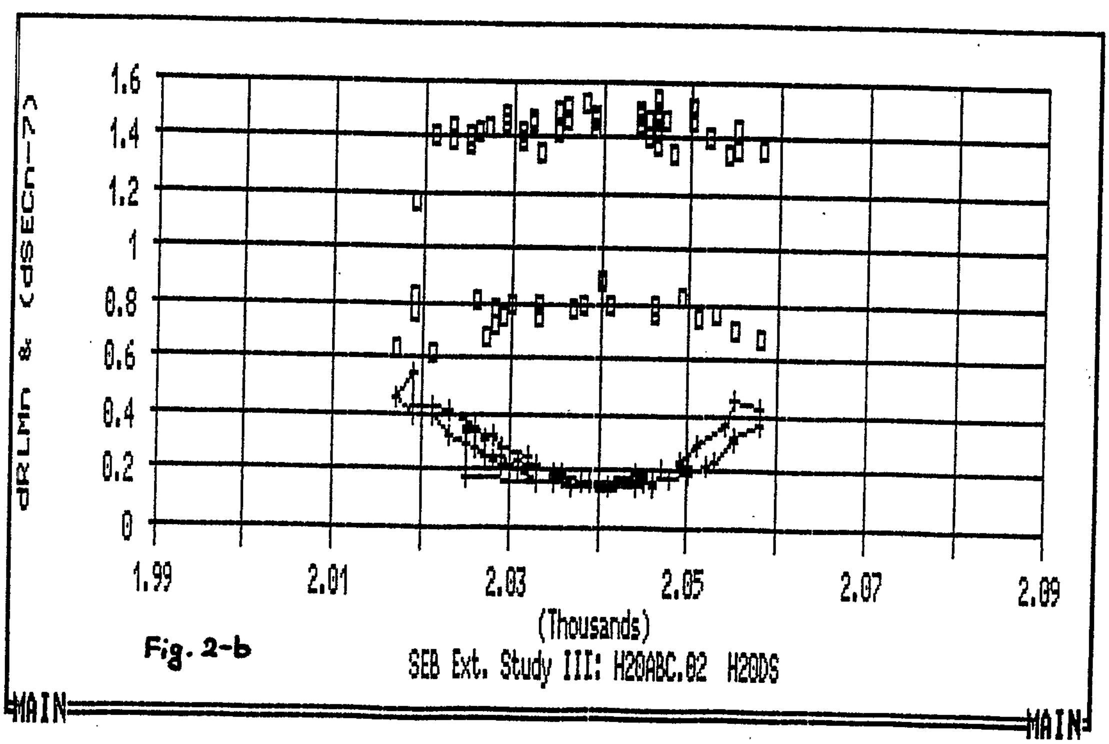

dRLMn & <dSECn-7>
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.99
2.01
2.03
2.05
2.07
2.09
(Thousands)
SEB Ext. Study III: H20ABC.02 H20DS
MAIN
MAIN

Fig. 2-b

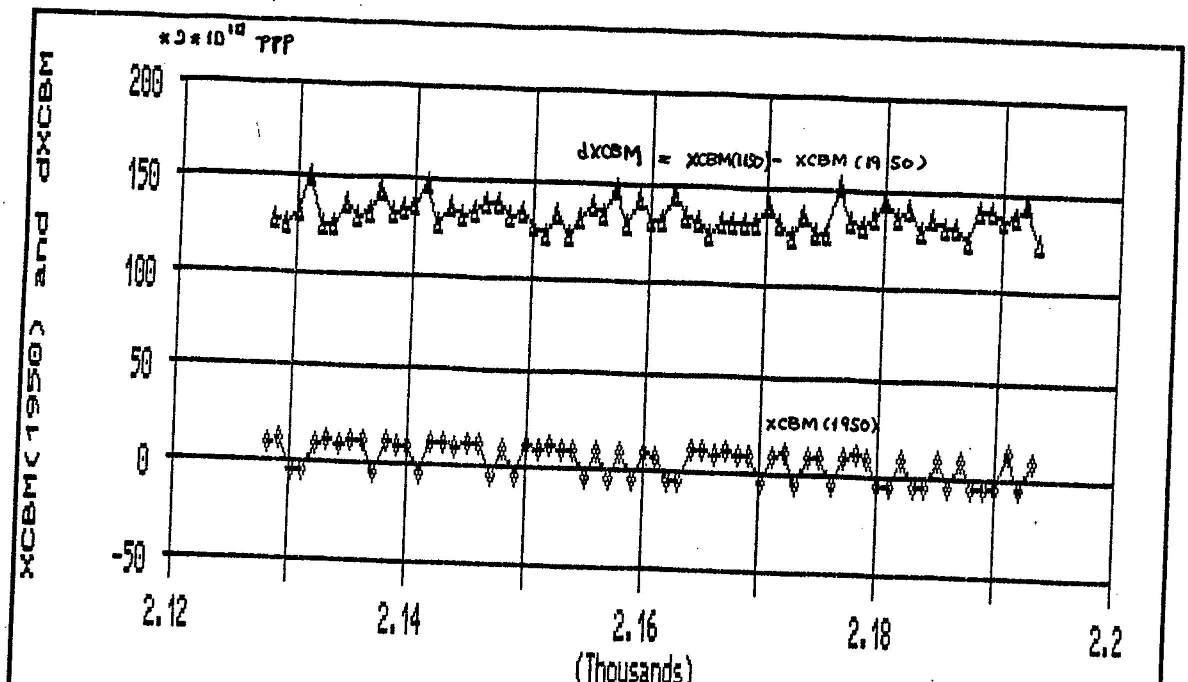


Fig.2-c Pulse # (var.=H2ODS)

MAIN MAIN

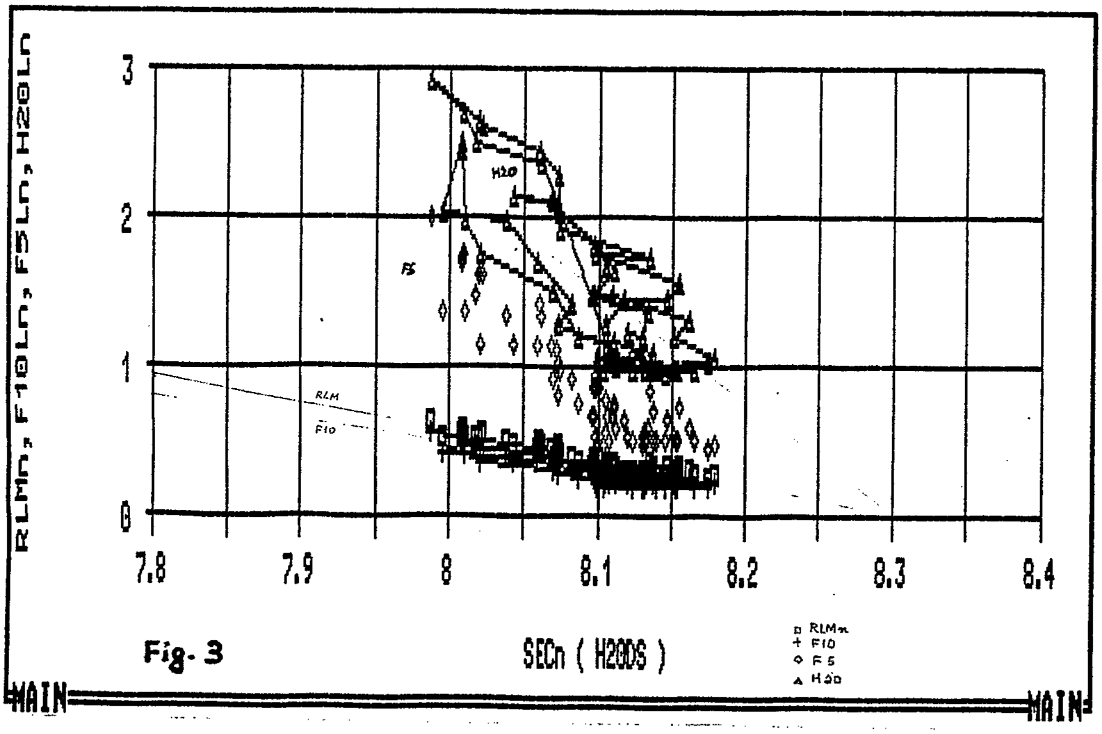

RLMn, F10Ln, F5Ln, H20Ln
3
2
1
0
7.8
7.9
8
8.1
8.2
8.3
8.4
H20
F5
RLM
F10
SECn (H20DS)
RLMn
F10
F5
H20
MAIN
MAIN

Fig. 3

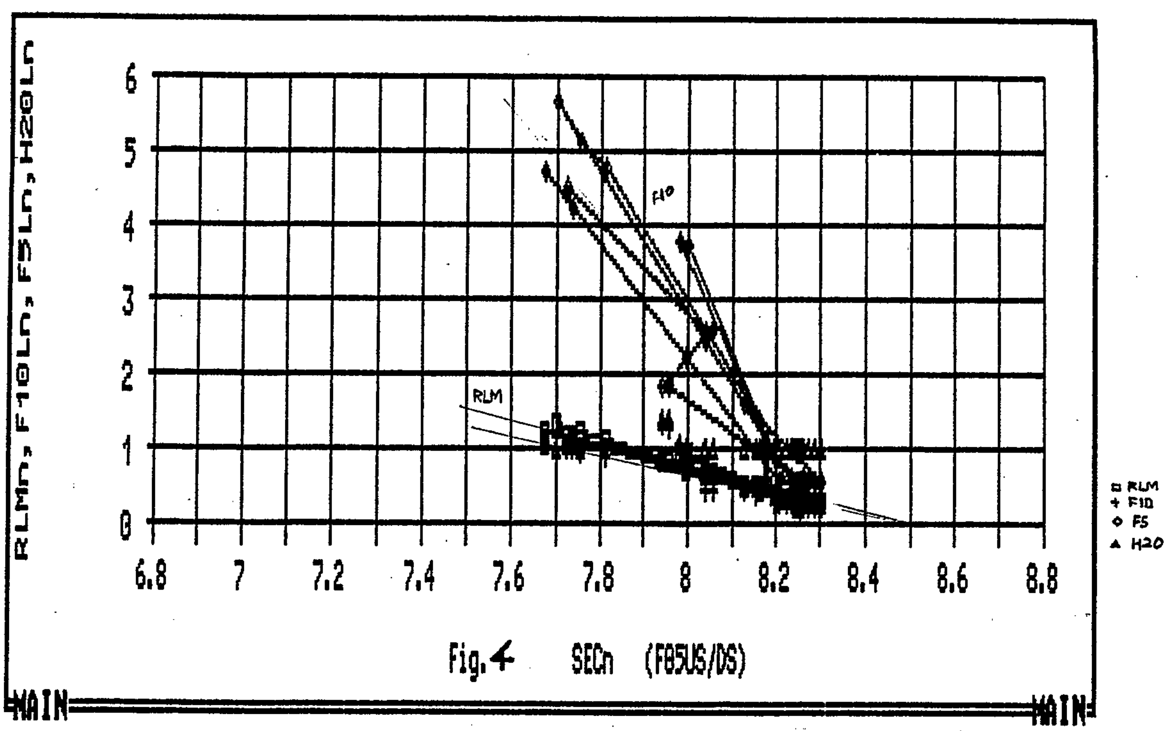

RLMn, F10Ln, F5Ln, H20Ln
6
5
4
3
2
1
0
6.8
7
7.2
7.4
7.6
7.8
8
8.2
8.4
8.6
8.8
F10
RLM
SECn (F85US/DS)
RLM
F10
F5
H20
MAIN
MAIN

Fig. 4

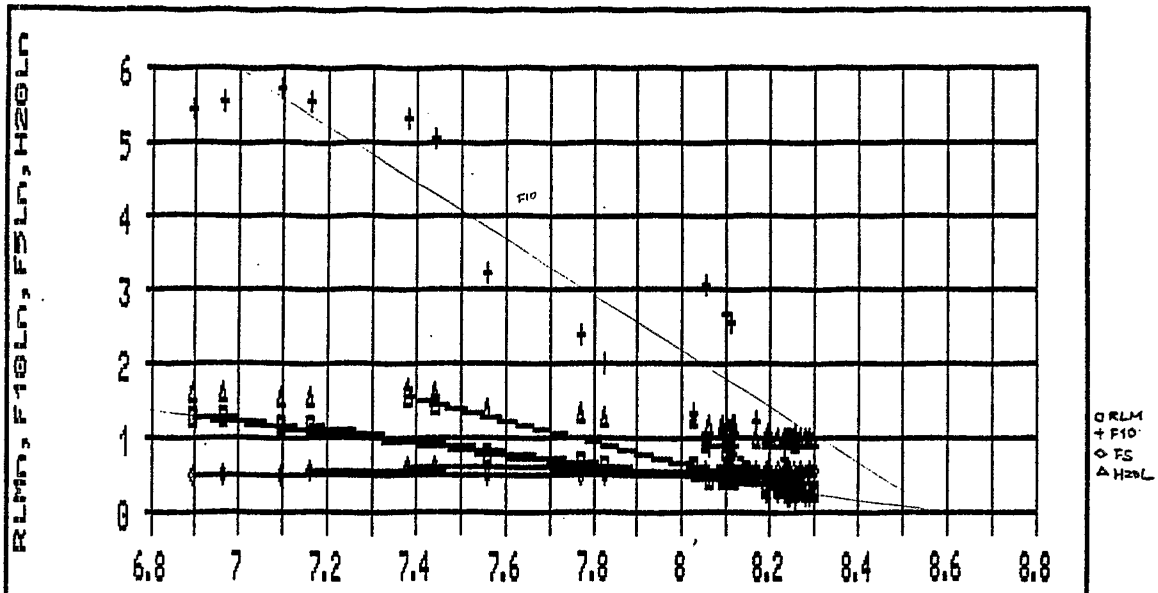


Fig. 5 SECn (F10US/DS)

MAIN MAIN