A Process to Evaluate Lead Cable Current Responses

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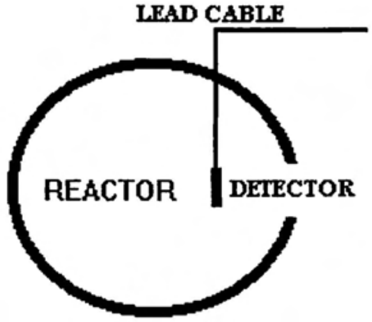
1.0 Introduction

In-core flux detectors (ICFDs) create an electrical current from neutron or gamma irradiation. The generated current travels along a lead cable (LC) to a remote amplifier where the current is evaluated (see Figure). These flux detectors are essential for reactor control and for initiating shutdown systems when local flux becomes too high.

One disadvantage with the flux detector lead cables is that they generate their own current. This current is different for each lead cable and is not well understood. This creates an uncertainty in the net detector signal.



2.0 Summary

This paper describes the Lead Cable Current Analysis Process. It provides a method to statistically separate and determine the LC current response to a flux transient (i.e. reactor trip) for a set of vanadium (V) or other exponentially responding detectors. It also determines the average prompt response of the vanadium detectors without the LC current.[1]

Using this process to evaluate LC current responses in CANDUs should increase our understanding of the LC current characteristics. This process can be run at various stages of detector life to estimate the effect of burn-up on LC currents. This may ultimately allow for detector signal correction (as a function of burn-up) to improve accuracy.

3.0 Process Description

3.1 The detector+LC current is recorded for a number of vanadium detectors during a reactor trip or other flux transient. A sampling speed of 0.1 Hz is adequate, a sampling speed of 10 Hz or more is ideal.

3.2 The pre-trip steady-state LC current or LC response is simulated for each V detector considering LC burn-up, local flux, LC detector sensitivity.

3.3 The prompt response for each LC+detector to the transient is determined from the data collected in 3.1 above. It can be determined in a number of ways, one of which is to compute the detector+LC response to the trip at some time after the trip, and remove the expected exponential decay responses from the vanadium detector and LC. The remaining response will be approximately prompt.

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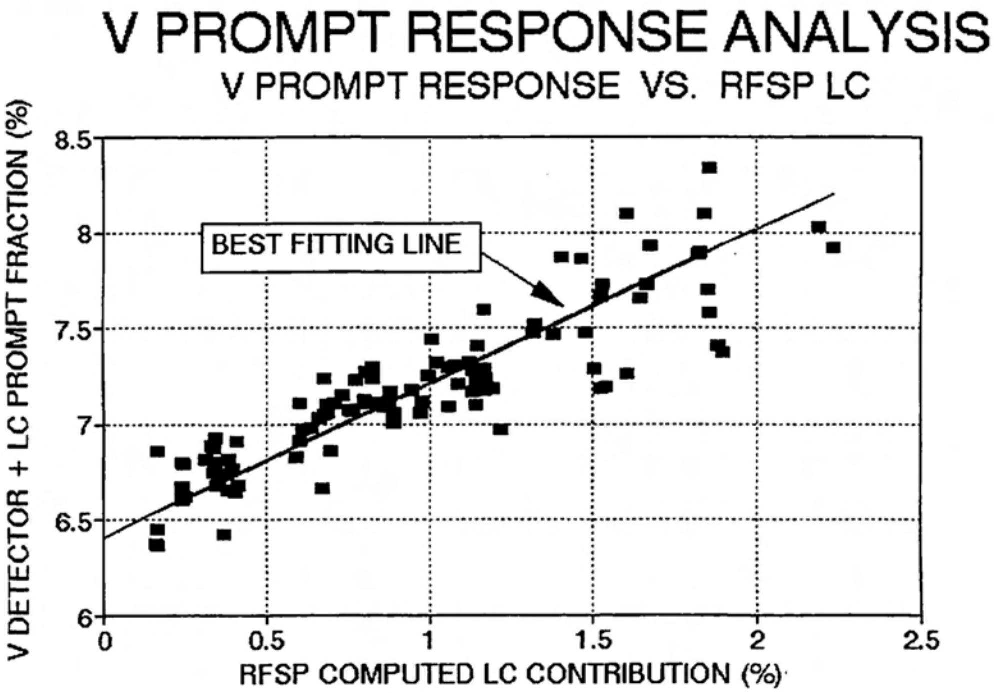
[1] Vanadium Detectors have a prompt response of about 5-10% of their total signal.

3.4 The prompt responses of the LC+detectors from 3.3 above is compared to the simulated LC currents from 3.2 above. A best fitting function is determined for the data which reveals:

- The average prompt fraction of the V detector set without the LC current. This is the Y-intercept[2].
- The slope of the function is the average ratio between the actual LC current responses and the simulated LC currents.

4.0 Results

Below is an example for a planned SDS1 reactor trip from 75% FP at PLGS on 25 Dec 95. Plotted is the computed V detector + LC prompt fractions (102) versus the steady-state LC contributions simulated by RFSP (a flux simulation program). The best-fitting function to the data is shown:



The derived function reveals:

- The average prompt fraction of the V detector set without the LC current is the Y-intercept of 6.4%. This value is consistent with results from other tests.[1]
- The slope of the function is 0.8 %/% and is the average ratio between the actual LC current responses and the simulated steady-state LC currents. This value will be dependent on the LC prompt fraction and burn-up.[2,3]

The scatter of the results is due to measurement errors, simulation errors, and detector-to-detector response differences.

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2 The Y-intercept value is found by extrapolating the function to where the simulated LC current or current response is zero.

5.0 Computing LC Current Responses

The individual LC current responses can be estimated using Equation (1) assuming that each vanadium detector has a constant prompt fraction:

$$\Delta I_{lc,i} = I_{det+lc,i} \left(FP_{det+lc,i} - FP_{det,i} \right) \qquad (1)$$

Where:

$\Delta I_{lc,i}$	current response for LC i
$I_{det+lc,i}$	measured pre-trip current for detector i + LC
$FP_{det+lc,i}$	fractional prompt response for detector i + LC from 3.3
$FP_{det,i}$	average prompt fraction for a V detector (the Y-intercept of the function found in 3.4)

6.0 References

(1) J.C. HANDBURY, "Response Analysis of the Vanadium Detectors and Dummy Lead Cable to a Reactor Trip", PLGS Physics Internal Report PIR-96-010 [draft].

(2) B. SUR, "Comments on Re-analysis of V Detector Response and LC Contributions, Dated 1996 July 29", AECL Letter, 21 Aug 96.

(3) C.M. BAILEY, "Re: Estimation of Vanadium Detector Lead-Cable Contributions from Measured Prompt Responses on Shutdown", AECL Memo 66/12-66552-021-96502, 28 Aug 96.