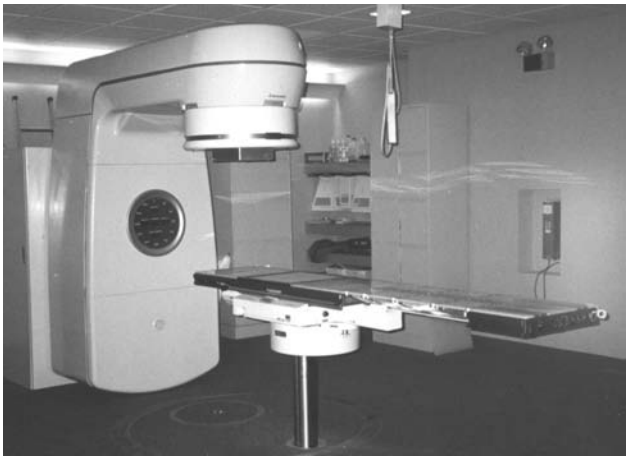
PowerLines

Application Note ZM-1
Detecting Loose Connections

Mains Impedance measurements can effectively detect and isolate loose electrical connections.



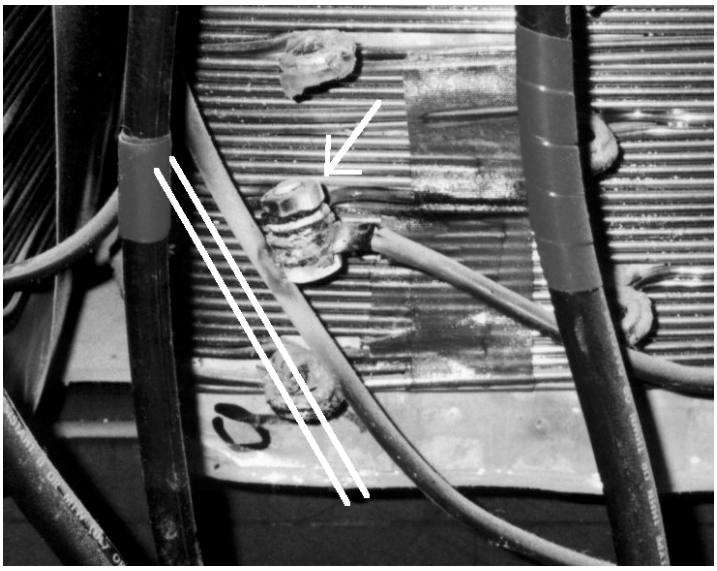
One method of treating cancer is through the use of a Linear Accelerator. This device is used to apply a focused beam of "hard" radiation at a tumor or cancerous cells. By properly focussing this beam, a dose of radiation sufficient to kill the cancerous cells can be applied, without killing healthy tissues nearby.

A Cancer Treatment Center was experiencing system problems with their Linear Accelerator. Output dose was fluctuating, requiring frequent re-calibration. This affected the patient throughput, interrupted treatment plans, and impacted the cancer center's profitability.

A ZM-100 Mains Impedance meter was used to measure the mains impedance as part of a Power Quality Audit. In the course of measuring mains impedance, an imbalance was detected at the input to the Linear Accelerator. Since an imbalance in mains impedance is extremely rare, the Power Quality engineer began to "walk the line back" making impedance measurements at accessible points along the power feeder.

By measuring the impedance at multiple points along the feeder circuit, the problem was isolated to the primary side of a 30 kVA isolation transformer. Close inspection of this device identified a loose connection that was in the process of overheating. This connection was causing impulses, voltage imbalance, and waveshape distortion, which were causing the Linear Accelerator problems.

Cleaning and tightening the connection eliminated the equipment problems, saving the customer close to $15,000 that would have been spent on a voltage regulator.

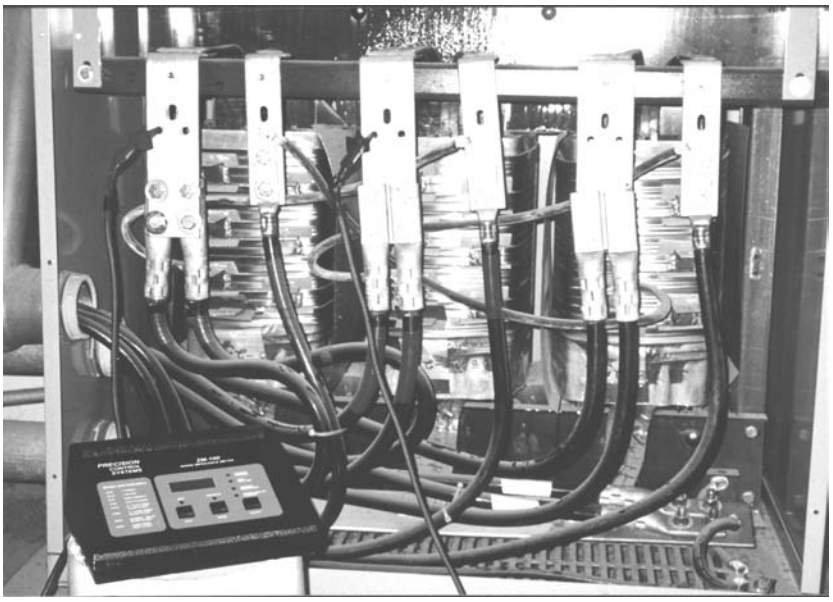


The arrow points to the transformer tap itself. The copper coil and connection wire in the vicinity of the tap also show signs of heating (conducted from the tap), resulting in a blackening of the transformer tape and a degradation of the wire insulation.

More dangerous - the adjacent conductor (parallel to the white lines) is a different 480 VAC phase. This wire is touching the overheated tap, and shows signs of insulation degradation and heating. A short circuit from this wire to the tap would cause a circuit breaker trip (best case) resulting in short term loss of Linac use. In worst case, this short circuit could cause an arcing fault that could damage or destroy the transformer, or possibly start an electrical fire.

- Static measurements (voltage and current) were not able to detect this problem
- Dynamic measurements (power quality monitoring) did not reveal this problem
- A close physical inspection (visual or thermograph) of the electrical system would have found this problem. However, the ZM-100 permitted the problem to be isolated to a specific device quickly, with a minimum of on-site labor

The ZM-100 is designed to measure impedance on 120 to 480 VAC systems safely and quickly. At left, the ZM-100 is shown connected to the 208 VAC secondary of a 225 KVA transformer.



Mains Impedance Measurements

Mains Impedance is a parameter that indicates the capacity of an electrical source. A Precision Control Systems Model ZM-100 was used to make impedance measurements at several points on the electrical system. This was used to determine system capacity, voltage drop, and provided the evidence that pointed to the loose transformer connection due to unbalanced impedance.

	30 kVA Transformer Primary		**30 kVA Transformer Secondary**		**Linac Panel LC-A1**	
	Voltage	**Impedance**	**Voltage**	**Impedance**	**Voltage**	**Impedance**
Black-Red	498.9 VAC	0.065 Ω	212.9 VAC	0.138 Ω	210.9 VAC	0.200 Ω
Black-Blue	212.7 VAC	0.062 Ω	211.7 VAC	**0.070 Ω**	212.7 VAC	**0.093 Ω**
Blue-Red	210.0 VAC	0.063 Ω	212.0 VAC	0.144 Ω	210.0 VAC	0.206 Ω
Red-Neutral			121.4 VAC	**0.115 Ω**	118.8 VAC	**0.119 Ω**
Blue-Neutral			121.7 VAC	0.054 Ω	121.1 VAC	0.086 Ω
Black-Neutral			121.5 VAC	0.060 Ω	120.4 VAC	0.063 Ω

BOLD *measurements above are unbalanced, and indicate a problem of some sort. Impedance imbalance was seen on the secondary side of the transformer as well as at the load, but not on the primary of the transformer. A loose connection was suspected within the transformer itself.*