USE OF A PORTABLE LINEAR ACCELERATOR TO RADIOGRAPH BRIDGE COMPONENTS

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This paper will discuss the characteristics and uses of portable linear accelerator x-ray sources for use in field inspections of bridges and associated structures.

OVERVIEW

The advent of a portable source of very high energy x-rays has opened up inspection possibilities in a wide range of environments. Applications have included such areas as concrete and steel bridges, nuclear waste containers, nuclear and fossil power plants, surface and airborne transportation systems, space launch systems and other thick section problems that cannot be imaged using other NDT methods.

CHARACTERISTICS OF PORTABLE LINEAR ACCELERATORS

Topics will include:
1. Portability
2. High Output
3. Thick Section Penetration
4. Short Exposure Times
5. Image Quality/Resolution

PORTABILITY

Perhaps the most notable attribute of these systems is their portability. For example, a typical 6 Mev unit consists of a remote van mounted control and power module and an at-site r.f. generator coupled via flexible wave guide to the accelerator. The accelerator, at 100 pounds in a roughly 12" cube is the actual working point of the system. Compare this to the refrigerator sized, crane mounted units commonly used for indoor radiography and the real value of this new technology is obvious.

HIGH OUTPUT

The output of portable systems matches that of the fixed systems. That means energies of from 1Mev to 11Mev at photon fluxes of from 15 to 3000R/Min/1 Meter. The control and r.f. drive units are basically the same for each energy, with different accelerators being fitted as needed. This gives the user great latitude for developing exactly the system to meet his needs without the large price differences normally associated with an increase in output.

THICK SECTION PENETRATION

As with output, portable systems can match the penetration capability of fixed units in all respects. An important thing to remember is that these energies have never been available in the field before the appearance of these accelerators. That means otherwise uninspectable areas can now be considered as candidates for NDE examination. For instance, a 48" pre-stressed concrete bridge beam with corrosion indications can now be examined for loss of section in it's tensioning members.

SHORT EXPOSURE TIMES

The very short exposure times, most commonly a few minutes or less, characteristic of accelerators make them much less sensitive to effects such as vibration or ambient radioactivity that limit other work. Radiation perimeter control is likewise made much easier and safer because of the very short exposure times.

IMAGE QUALITY/RESOLUTION

In addition to the shorter exposure times and high energy/output, accelerators have very small focal geometry (<2mm). This is less in most cases than that of conventional x-ray systems and certainly much smaller than isotopic sources. This fact produces much smaller geometric unsharpness values at equivalent source to film distances (SFD). Much greater SFD can be used to achieve higher sensitivity (i.e. 1/1T -vs- 2/1T) and finer film resolution (i.e. type M -vs- type AA) than has been otherwise possible.

FIRST USE IN CALIFORNIA
In 1988, failures of vertical suspender cables on the Guy West Pedestian Overcrossing Bridge in Sacramento prompted a major research effort to determine the condition of other bridges of similar design. The first application was on the San Francisco Bay Bridge between San Francisco and Oakland. This is a major cable suspension bridge utilizing vertical suspender cable.

The failures in the Guy West Bridge had occurred inside the socket by which the cable attaches to the bridge. Isotope radiography was acceptable for examination of these smaller cables but could not image the large cables and sockets on the Bay Bridge.

Tests of the Bay Bridge sockets using a portable linear accelerator gave clear radiographs of the acceptable condition of it's sockets as well as providing base line data for future comparisons.

Other similar inspections have been done on the Golden Gate Bridge, the Vincent Thomas and Gerald Desmond bridges in Long Beach, the Meridian bridge in northern California.

OTHER APPLICATIONS
The accelerators success has not been limited to steel structures. A number of inspections were done in support of earthquake damage evaluations after the Loma Prieta quake on various structures including bridges and buildings around the San Francisco area.

A particularly interesting application was analysis of corrosion indications and collision damage on the Richmond/San Rafael Bridge across the northern end of San Francisco Bay. The accelerator and film were positioned along the bridge from a 21 ft. boat. Radiographs gave clear data on the condition of all suspect tension members.

Caltran's use of the portable accelerator has not been limited to bridges structures. One of the most successful applications was the analysis of a bridge drainage pump associated with the Dumbarton Bridge located near San Jose, Ca.

CONCLUSIONS
The experience of Caltrans has shown the portable linear accelerator to be a safe and effective method for radiographic inspection of a wide variety of concerns within the transportation infrastructure of California. The consideration of this technology is recommended for those faced with the examination of large thick section structures that would otherwise defy analysis.