N91-18190

DEVELOPMENT AND APPLICATIONS OF NONDESTRUCTIVE EVALUATION AT MARSHALL SPACE FLIGHT CENTER

SURFACE INSPECTION FACILITY:

The Surface Inspection Facility provides magnetic particle, penetrant, and remote visual inspection capabilities. Both in-plant and field inspection capabilities exist for all three techniques. The permanent lab facilities include a large fixed magnetization station for magnetic particle inspection, a well-ventilated penetrant inspection station with dark room and microscopic viewing capability, and a photographic laboratory to provide documentation of any surface inspection performed. A wide variety of portable equipment is available for field inspections. These include: both stiff and flexible-leg magnetizing yokes and field strength instruments for magnetic particle inspection, portable penetrant systems, and more than two dozen flexible/rigid borescopes and fiberscopes.

TYPICAL INVESTIGATIONS:

* Detection of surface and near-surface cracks in weldments
* Detection of seams and foldovers in castings
* Monitoring of bearing wear during SSME operations
* Detection of structural failure in tie-down hardware

ADVANCED COMPUTED TOMOGRAPHY INSPECTION STATION (ACTIS) :

ACTIS is a state-of-the-art computed tomography facility which uses digital x-ray technology to produce cross-sectional images of space components nondestructively. ACTIS utilizes four x-ray sources, a high-speed array processing computer, and variable system geometry to allow optimization for virtually any test object up to 4 feet in diameter. Image processing capabilities include: solids modelling, multiplanar reconstruction, and a wide variety of statistical and data display options. Images may be archived to either 1600 bpi magnetic tape or 2 gigabyte optical disk as desired. Raw scan data may be archived to optical disk for later recall.

TYPICAL INVESTIGATIONS:

* Characterization of flaws in composite materials
* Detection of inhomogeneities in metal castings
* Verification of internal geometry
* Development of acceptance criteria for SRM nozzle

NDE DATA EVALUATION FACILITY:

The NDE Data Evaluation Facility provides the capability for mapping NDE data from any source (within or outside MSFC) and mapping it into a common frame of reference. The data may then be directly compared to each other or to other data sets, such as

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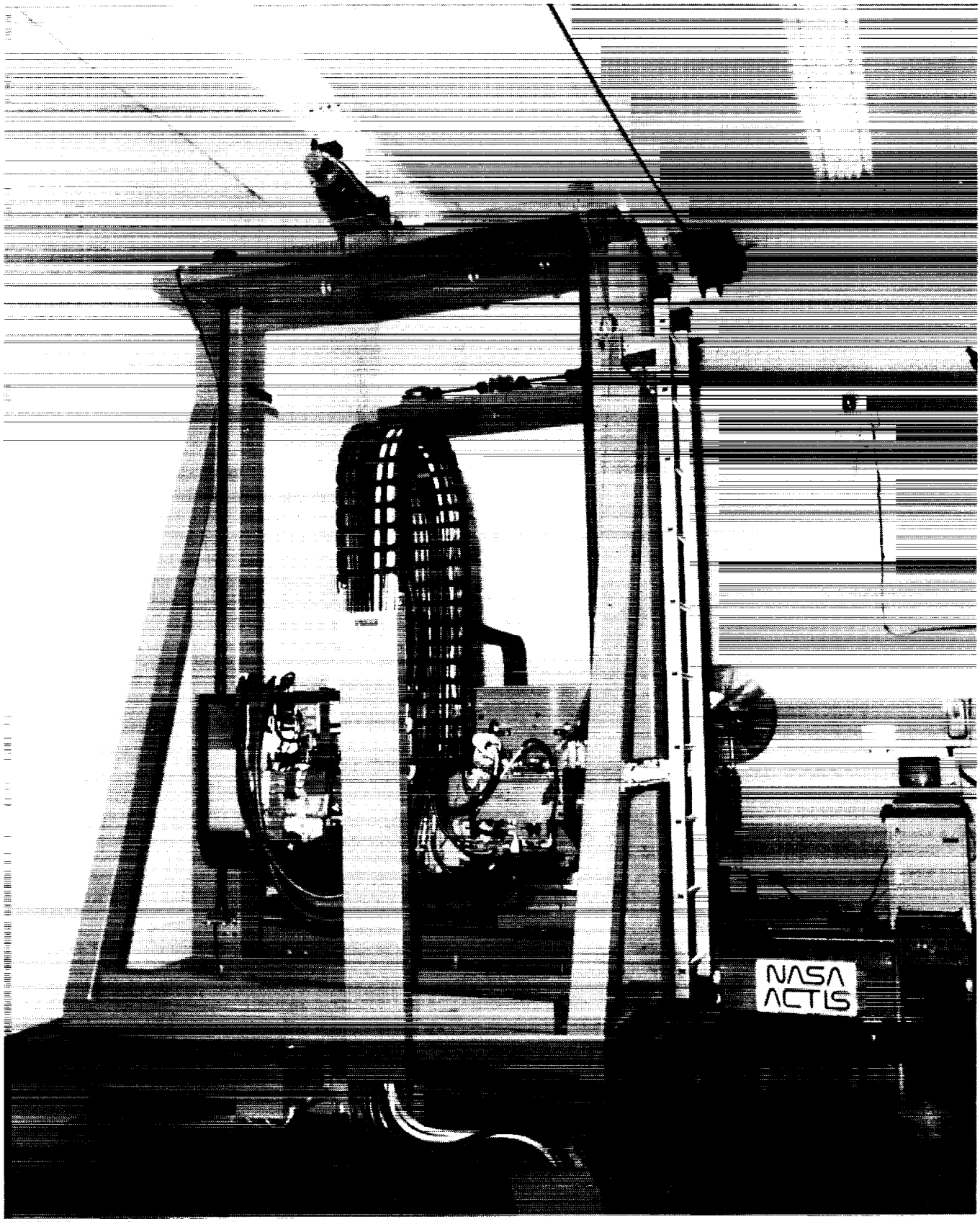

MSFC COMPUTED TOMOGRAPHY SYSTEM

mechanical test data. Additional capabilities such as mechanical test cutting plan development, statistical analyses, and the correlation of NDE to materials properties are also provided. These capabilities are provided primarily by the Integrated NDE Data Reduction System (INDERS), a network of three digital computers and specialized software. The center of the network is the MicroVAX II computer, which is capable of handling large data sets with relative speed. One IBM AT and one Tektronix 2330 Workstation allow some off-line processing of smaller data sets.

TYPICAL INVESTIGATIONS:

* Inspection of SSME turbine blades for microporosity
* Post-fire evaluation of PAM nozzles
* Development of acceptance criteria for SRM nozzle
* Development of materials properties for carbon-carbon

THERMOGRAPHIC TEST DEVELOPMENT FACILITY

Thermography is and NDE technique which makes use of an infrared camera system and digital image processor to monitor the infrared energy emission from the surface of a part under investigation. The system is capable of resolving minute temperature variations, of as little as 0.1 degrees C. The image processor utilizes a number of image enhancement techniques to increase temperature difference resolution.

TYPICAL INVESTIGATIONS:

* Detection of subsurface disbond conditions in samples representative of the SRM
* Detection of ice formation on the surface of the ET
* Detection of ice during warm up of cryo-cooled SSME turbopump shafts

RADIOGRAPHIC TEST FACILITY

The Radiographic Test Facility, comprised of a radiation-shielded cell and adjacent control room, film processing rooms, and a film reading area, provides the capability of radiographic evaluation of hardware. Portable lower energy x-ray generating units are located in the facility, as well as permanently mounted units capable of producing 150 kev and 320 kev x-rays. Processed film radiographs are analyzed in the film reading area to detect possible defects in the parts under investigation.

TYPICAL INVESTIGATIONS:

* Evaluation of welding processes
* Assessment of internal configuration
* Detection of materials anomalies
* Determination of structural integrity

REALTIME RADIOGRAPHIC TEST FACILITY

Realtime radiography (RTR) eliminates the use of film by replacing it with an image intensifying unit and video system, allowing viewing of a radiographic image on a video monitor while x-rays are passing through the test specimen. The specimen is placed within a radiation-shielded cabinet, and x-rays are generated by a microfocus x-ray tube with a maximum energy of 160 kev. The microfocus tube can be used to produce magnified images of up to 80X. A computer is also an integral part of the system and equips it with the capability of digitizing and enhancing images received from video.

TYPICAL INVESTIGATIONS:

* Detection of flaws in composite parts
* Examination of electrical components
* Determination of internal dimensions
* Failure analyses support

EDDY CURRENT RESEARCH FACILITY

The Eddy Current Research Facility provides the capability to perform critical development of eddy current applications for various aerospace components. Specific capabilities include: measurement of materials surface conductivity, determination of thickness of films and coatings, interrogation of material inhomogeneity, and detection of surface or near-surface crack-like flaws. Refinements in eddy current tooling and adapters have led to improved detection of flaws in previously inaccessible locations.

TYPICAL INVESTIGATIONS

* Nickel/Hydrogen battery cell girth weld investigations
* Weld wire material sorting
* Advances in SSME heat exchanger weld inspection
* Improved detection of flaws in clevis pins

ACOUSTIC EMISSION MONITORING SYSTEM

The Acoustic Emission Monitoring System makes use of transient electrical energy that is spontaneously released when materials deform, fracture, or are subjected to stress. Sensors are placed on the test object and are connected to an acoustic processor. The processor monitors both the amplitude and number of events (instances of energy releases) that occur during the test. The amplitude and number of events are displayed on the processors CRT and also in hardcopy form through a strip chart recorder.

TYPICAL INVESTIGATIONS

* FWC Structural Test Article Hydrostatic Test Monitoring
* OMV Composite Tank Test Monitoring
* Carbon-Carbon Nozzle Hydroburst Monitoring
* Monitoring of Test Stand Pressure Vessels and High

Pressure Lines

ADVANCED ULTRASONIC TEST STATION (AUTS)

AUTS was designed for ultrasonic inspection of composite material symmetrical components, with an operational envelope of 8" to 48" diameter and 2 to 15 foot length. Filament wound motor cases and bottles, wound in the adjacent Productivity Enhancement Facility and SRM sub-scale components were primary targets of capability development. The AUTS employs a dual water squirter coupling mode, as well as an air-coupling mode. The system has remote manipulation capability for both transducers and can be operated in the through-transmission or pulse-echo modes. Scan data is displayed in color or gray scale at the control console. Digital, amplitude, or time-of-flight information is displayed and stored, along with C-scan and depth data. Flaw resolution is 0.250" diameter in 3" of graphite epoxy.

TYPICAL INVESTIGATIONS

* PAM-D Exit Cone Evaluation
* Composite Ballistic Environment Generator (BEG) Motor Cases
* Solid Propulsion Processing Technology Investigations
* Materials Characterization Investigations

ULTRASONICS TEST FACILITY

The Ultrasonics Test Facility consists of both hand scan contact and immersion noncontact ultrasonics used in the interrogation of internal anomalies and bondline integrity. The immersion capability is quite versatile, providing a capability to perform either through-transmission or single-side pulse echo scanning of flat panels or cylindrical and conical shaped objects. The microprocessor controlled system produces hardcopy ultrasonic data displays in flat X-Y or polar scans. Portable contact ultrasonic inspection equipment provides a capability to ultrasonically interrogate hardware too large for the immersion tank, or materials that cannot be immersed.

TYPICAL INVESTIGATIONS

* Detection of cracks in weldments
* Characterization of anomalies
* Impact damage tolerance studies
* Internal characteristics of plates and castings

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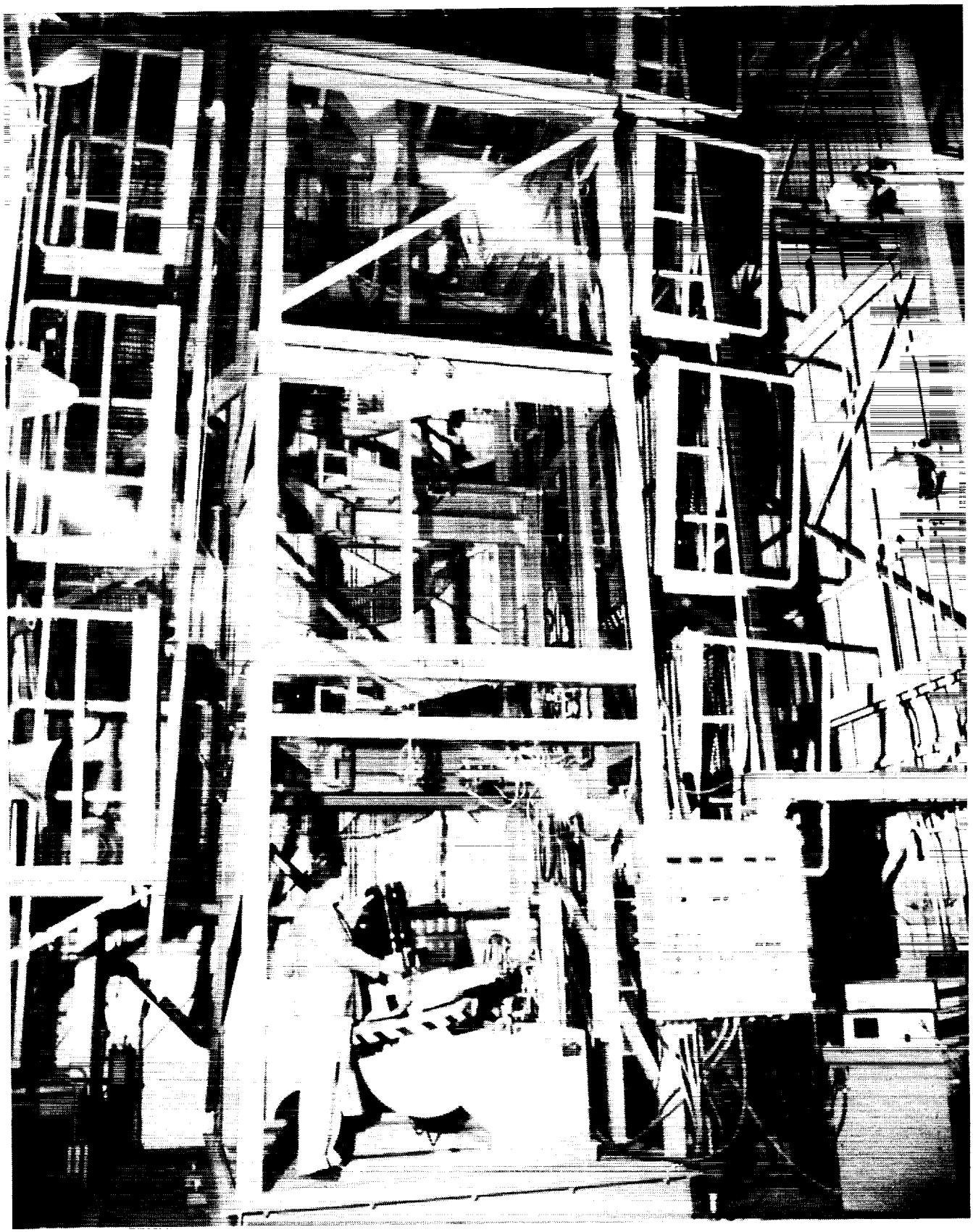

MSFC AUTOMATED ULTRASONICS STATION

COMPUTER CONTROLLED SCANNING/OPTICALLY STIMULATED ELECTRON EMISSION SURFACE CONTAMINATION MEASUREMENTS

Computer controlled contamination scanning (CONSCAN) is a system developed by MSFC utilizing the optically stimulated electron emission (OSEE) technique for scanning solid rocket motor (SRM) cases for surface contamination prior to critical bonding operations.

The CONSCAN system has the principal advantages of providing the sensitivity and spacial resolution necessary when scanning large areas, to ensure that surfaces are sufficiently free of contaminants that reduce bond strength.

Scanning the surface with the CONSCAN provides a map of surface contamination levels, which clearly identifies those areas that require further cleaning; rescanning after the additional cleaning operation provides results of that recleaning. This data provides a permanent record of surface cleanliness levels. This record may be used at a later date to help identify the specific process during which contamination occurred and to correlate surface cleanliness levels with subsequent debond locations.

Principle of operation of the OSEE may be briefly described as follows. When a surface is exposed to ultraviolet (UV) light of sufficient energy, photoelectrons will be released from the surface. Contaminants on the surface will normally reduce the number of these photoelectrons which are emitted. The OSEE sensor has two major components: the electron UV light source and the electron collector. The photoelectron current emitted from the irradiated surface is measured by the electron detector. This current can be calibrated to the contaminant level on the surface.

The technique as applied to measuring contaminants on surfaces was developed and reported by Tennyson Smith in April 1975. He demonstrated both the sensitivity of the technique to contaminant level and bond strength variation due to contamination.

The technique with MSFC support was utilized on the External Tank foam debond study in 1979. This technique was instrumental in identifying the surface contaminant causing debonds as being silicone which originated from simultaneous processing of other hardware in the same building.

Since the original instrument configuration in 1979, significant OSEE instrument improvements have been implemented, including: increased signal amplification, noise filtering, higher output UV light sources, compact sensor configurations, and computer data analysis.

MSFC initiated a study of the SRM debonds associated with propellant liner insulation to case, and the carbon and glass phenolics used in the nozzle. Research studies determined that the corrosion; protective HD-2 grease used on the SRM case has a significant effect on bond strength. Quantitative levels that affect bond strength and associated OSEE signal levels were determined by extensive laboratory testing. This calibration data was incorporated in the design, development, and implementation of the CONSCAN system.

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