

THE IOWA DEMONSTRATION LABORATORY FOR NDE APPLICATIONS -  
A NEW APPROACH TO NDE TECHNOLOGY TRANSFER

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## INTRODUCTION

Nondestructive evaluation plays an extremely important role in a number of the typically large, high-tech industries such as aerospace, nuclear, automotive, and petroleum. These industries and the federal government have made substantial investments to develop the equipment and perfect the various inspection techniques. With this substantial investment in the technology, there are many NDE tools currently available for transfer to the general manufacturing community. These tools are becoming increasingly important as companies, large and small, strive to improve product quality in order to increase customer satisfaction and maintain their particular market share.

Iowa State University (ISU) has long been involved in basic and applied NDE research at its National Science Foundation Industry/University Cooperative Research Center. ISU's Center for NDE is nationally and internationally recognized as a leader in its field. The state of Iowa has recognized the important role NDE is playing in primarily large industry and has moved to make the expertise at the Center available to Iowa's typically small manufacturing companies. In 1992, the Iowa Demonstration Laboratory for NDE Applications was established with state funds to facilitate the transfer of technology from the Center for NDE to Iowa industry. The purpose of the Iowa Demonstration Laboratory for NDE Applications (IDL) is to assist manufacturers in the adaptation and implementation of NDE technology. The IDL provides demonstration, diagnostics, education, and service to Iowa manufacturers with the following objectives:

- To promote utilization of nondestructive evaluation technologies by the engineering, and manufacturing communities.
- To establish a mechanism to assist in implementation of these technologies
- To provide a capability for education and demonstration of the technologies

## FACTORS LEADING TO ESTABLISHMENT OF IDL

Most of Iowa's manufacturing companies tend to be small in terms of the number of people they employ. As can be seen in Figure 1, A, 99 percent of the firms have fewer than 1000 employees and nearly 90 percent of the firms employ less than 100 workers. Yet, the manufacturing sector is very important to Iowa's economy as it pays the highest average annual wage as shown in Figure 1 B. In our efforts with these small to medium size companies, we have found considerably different needs from those of a large corporation. The personnel resources, capital equipment, and access to technology and training are often more limited for the small to medium sized manufacturer. In most cases the engineering staff is small to non-existent, and engineers have a broad range of responsibilities. Many, however, are struggling with process control and quality control issues as customer satisfaction programs such as TQM and ISO 9000 continue to drive the demand for higher quality products. Nondestructive evaluation offers many possible solutions to these companies, but the level of awareness and understanding of the technology must be raised.

Iowa State University has a history of NDE research which dates back to 1980 when the United States Air Force funded the Program for Quantitative NDE, the same program responsible for the Annual Review of Progress in QNDE. In 1985, the Center for NDE officially began as one of the National Science Foundation (NSF) Industry/University Cooperative Research Centers. The NSF program strives to match industries with common needs to research universities with expertise in that area. The NSF program continues to be one of the strongest of the NSF centers with a current membership of 27 and a yearly budget of \$5.0 M. Over the years, the ISU NDE program has continued to grow and now also includes the National Institute of Standards and Technology Center for Integrated Design, NDE and Manufacturing Sciences and the Federal Aviation Administration Center for Aviation Systems Reliability. Because of this strong technology base and the identified needs of Iowa industry, the Iowa Demonstration Laboratory for Nondestructive Evaluation was formally established in September of 1992 to serve as an NDE resource to Iowa manufacturers. A time line of the programs at ISU is shown in Figure 2.

## DEVELOPMENT AND OPERATION OF IDL

A significant component of the development of the IDL operational concept has been the input of industry. In 1991, an open house was held at CNDE to solicit the input of small to medium size manufacturers from around Iowa in defining the program goals, mode of operation, and services to be provided. The identified needs focused in four main areas: demonstration, diagnostics,

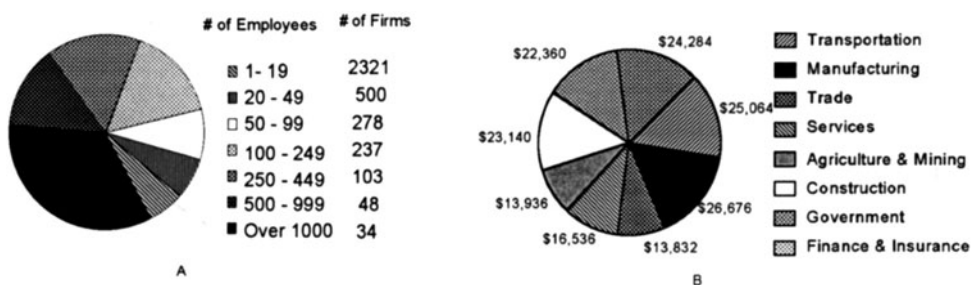


Figure 1. A - Number of employees per firm. B - Average annual wage by employment sector. Source: Iowa Department of Employment Services

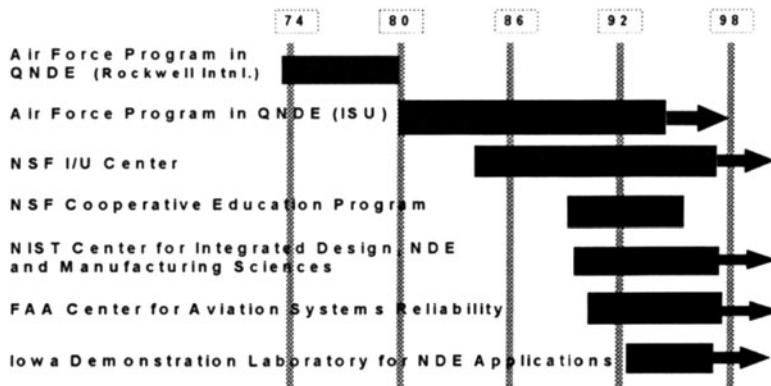


Figure 2. ISU NDE timeline.

education, and service. Each of these needs is addressed in the current operation of the IDL as can be seen in Figure 3 and are discussed further below.

**Demonstration:** Access to "state of the market" NDE equipment was emphasized at our initial workshop. The attendees recognized the need to make informed decisions about implementation of any new technology, including NDE. The IDL facility and equipment selection criteria considers portability, ruggedness, ease of use, and time to implement in an industrial environment. The IDL is available to assist with technique assessment in a "hands-on" fashion providing an independent, unbiased view. Additional technical expertise is available from CNDE staff on an as needed basis. Capabilities in four of the five major NDE techniques are currently operational (penetrant inspection, magnetic particle inspection, ultrasonics, and eddy current). X-ray capability will be available in 1995. Portable equipment and specialized instrumentation exists for all of the techniques, except X-ray, which allows us to take the demonstration concept to the factory floor. Figure 4 shows a list of major equipment.

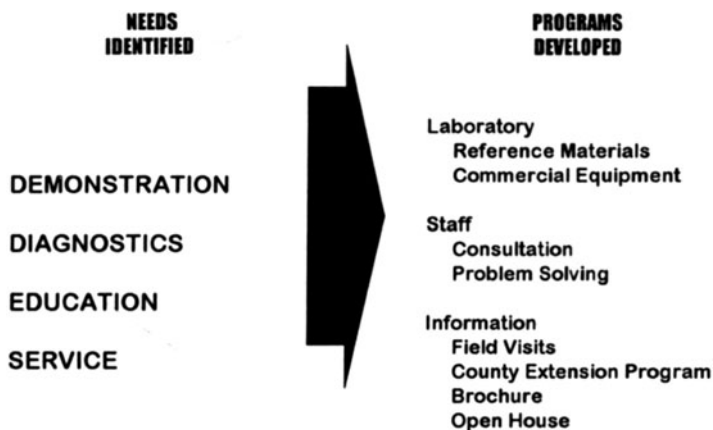


Figure 3. Programs were developed to address the four primary needs identified by industry.

<u>Dye Penetrant</u>	<u>Eddy Current</u>
– ZA-28 Fluorescent Dye System	– ZETEC MIZ-40
– Fluorescent Portable Kit	– PAC 1 Conductivity Meter
– Visible Portable Kit	– Computer Controlled Scanning System
– Portable Black Light	<u>Ultrasonics</u>
<u>Magnetic Particle</u>	– Stavely Flaw Detector
– Magnaflux Type H710RETRO Unit	– Panametrics 26DL Thickness Gage
– Magnaflux Demag Unit	– Computer Controlled Immersion Scanning System
– Magnaflux Yolk (Y7 AC/DC)	<u>X-Ray</u>
– Magnaflux Type L-10 Magnetic Coil	– Phillips MG 161 Generator
– Portable Mag. Particle Kit	– Agfa NDT M Film Processor

Figure 4. IDL major equipment list

In setup of the IDL facility, we have concentrated on commercially available equipment. This ensures that once a procedure or approach is developed in the laboratory, it can be transitioned to the factory floor. The facilities are used in a “mock up” fashion, with the client providing a sample of the component to be tested. We then work with them to develop a viable procedure, demonstrate that procedure using IDL facilities, and provide them with the information they need to make an informed decision about implementation. Instances which call for more sophisticated or quantitative equipment make use of CNDE facilities on a non-interference basis. The combination of “state of the art” and “state of the market” equipment provides the capability to meet almost all requests that come in. One of the benefits of the IDL concept is our ability to serve as a neutral, third party. With the IDL, manufacturers now have an independent source for information.

Diagnostics: Many of the requests that come into the IDL can be classified as “trouble-shooting”. In many cases, a problem has occurred in the manufacturing process and NDE techniques offer a means of determining the cause and ultimately defining the effectiveness of possible solutions. These requests are often critical to production and require a rapid turn around. The IDL role in these instances is to work with the company to identify possible solutions to their problems using NDE. In many cases this involves bringing a sample part into the lab and applying one or various NDE techniques to determine the optimum procedure for their particular application. Once a potential solution is found, it is up to the company to pursue use of the procedure with their own resources or contract with a commercial NDE lab.

In those instances where a production problem has been found or is suspected, the client is often interested in knowing the extend of the problem, i.e., is this a single occurrence, a single lot, or a long term problem. This requires a staff knowledgeable of both NDE and manufacturing processes and the current staff has a combined total of over 35 years of industrial technical experience. We will often work with other service providers such as the Iowa Manufacturing Technology Center (MTC) to bring in process control experts once we have completed the NDE part of the project. We have referred clients to, or worked in cooperation with, the Iowa Castings Center (castings), the Iowa Plastics Technology Center (plastics), and the Iowa Companies Assistance Program (metals and ceramics).

Education: The specialized nature of NDE requires specialized training as well. NDE knowledge in the Iowa manufacturing community is limited and education opportunities are few. There are a number of community college programs around the country that offer two year degrees in NDT (nondestructive testing) and a more limited number that offer NDE programs at the BS or post baccalaureate level. Iowa State University has been a leader in NDE education with a full range of NDE courses including:

- Establishment of an articulation agreement with Northeast Iowa Community College which allows students to receive both an associates degree and a Bachelor of Science degree in a 2 plus 3 year program. Efforts are underway to extend this arrangement to other community colleges in the upper midwest.
- Option of an NDE minor at the BS level to ISU engineering students.
- Post graduate education at the MS and Ph.D. levels. Approximately 50 students are currently involved at this level.
- Development of NDE education programs for the Federal Aviation Administration to be used at the FAA Training Academy.
- Development of instructional videos in use by the major airlines for education of their maintenance instructors.

While the IDL builds on this impressive foundation, the needs of our clients are much different from the opportunities these more formal options offer. Many require only a basic understanding of NDE and are not interested in the in-depth theory these formal courses offer. Much of our effort to date in this area has focused on information dissemination. To facilitate the transfer of information about the program, a brochure which familiarizes the reader with NDE techniques was prepared in 1993 and roughly 2000 have been distributed. While the brochure provides some preliminary information about IDL, the primary purpose is to educate the reader on the typical NDE methods used in industrial inspection. This was the first step in development of NDE educational materials. We have also made presentations in over 30 of Iowa's 99 counties in cooperation with local extension and economic development staff. These presentations include definition and examples of each of the NDE techniques with demonstration and "hands-on" opportunities with portable IDL instrumentation. The development of "NDE Fact Sheets," one page summary sheets, which can be distributed either as a set or individually when a client is interested in a particular technique, have been developed and are used as part of our demonstration programs. Similar, but more extensive, introductory type seminars have been held at ISU in which participants have the opportunity to participate in the inspection of parts using both lab/shop and portable equipment. For individuals already familiar with NDE, focus group workshops are offered to keep participants informed of the latest advances in a particular inspection area. These three hour workshops are designed to provide a forum for participants to interact with CNDE experts to discuss common industry needs and whether state-of-the-art equipment and practices offer potential solutions.

Service: The industrial consensus is that the emphasis should be placed on service as opposed to long-term research and development projects. While the value of long-term research is acknowledged, in most cases the manufacturers are interested in a timely application to their product. The emphasis again is on the implementation of commercially available equipment and the application of existing technology. Our current operating policy allows for 40 hours of free support to Iowa companies, with longer term projects

possible in a fee for service arrangement. The IDL is careful to avoid routine type testing which is available from commercial labs in the for-profit private sector.

#### Approach

The IDL program structure is designed to meet the four needs identified above. Organizationally, the IDL is part of the Institute for Physical Research and Technology (IPRT) at ISU and receives administrative support and funding through this organization. In an effort to maintain our focus on NDE, we work closely with other service providers at ISU and around the state, including the Iowa Manufacturing Technology Center as shown in the model in Figure 5. The IDL staff works with the Iowa Manufacturing Technology Center, a NIST funded program that involves cooperative partners from around the state of Iowa including Iowa State University, Des Moines Area Community College, the Center for Industrial Research and Service (CIRAS), the Heartland Technology Transfer Network, the Iowa Technology Transfer Council, the Center for Advanced Technology Development, and the Ames Laboratory.

Each of these organizations possesses particular technology transfer skills and most have field staff in place around the state to assist Iowa manufacturers. This is a mutually beneficial arrangement in that IDL utilizes this network to funnel NDE issues back to ISU. This allows us to concentrate on our area of expertise, NDE, and we in turn serve as a NDE resource to the other service providers. We occasionally utilize technical resources and facilities available at the Center for NDE when the needs of the client requires access to the state of the art or longer term research and development efforts. This is also a mutually beneficial relationship in that it provides IDL with extensive scientific resources and provides CNDE staff with relevant industrial examples to validate their research. We also work with others in the Iowa Community College system, with trade associations, professional societies and economic development organizations. Our primary customers have been in the area of general manufacturing, castings, energy systems, and agribusiness

#### Services Provided

The requests for service which come to the IDL are varied. In our nearly two years of operation we have provided service ranging from long term contractual projects to telephone consultation, to

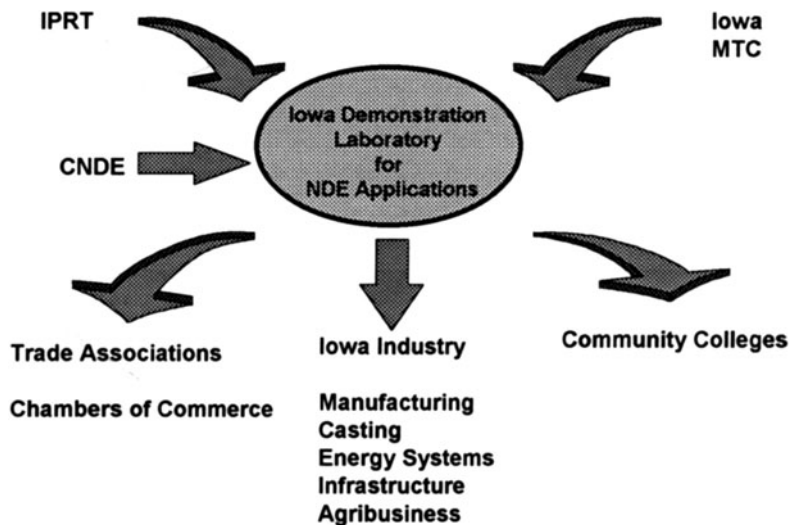


Figure 5. IDL working model.

over 50 Iowa companies. Consistent with objectives, the services we offer focus on raising the level of knowledge about NDE and helping companies implement or improve upon the use of NDE in their operation. Our client base has been predominantly in metal based manufacturing (60%) but has also included plastics/composites (25%) and ceramics (15%). Generally, our support efforts will fall into one of the six categories listed below.

- Explain/demonstrate the principles of the various nondestructive evaluation techniques.
- Evaluate inspection procedures for old, improved, or new designs and recommend alternative approaches.
- Assist in interpreting and obtaining compliance with customer QC specifications.
- Disseminate information on state of the art advances in the technology.
- Provide information on sources of equipment and routine testing services.
- Assist in making informed, unbiased decisions of equipment needs and purchases.

#### **BENEFITS TO INDUSTRY AND ISU CNDE**

The operation of the Iowa Demonstration Lab offer many benefits to both Iowa industry and the Center for Nondestructive Evaluation at Iowa State University. Benefits to industry include:

- Access to a fully equipped laboratory that offers hands-on opportunities to determine the usefulness of NDE on their part to solve their specific problems. Emphasis is placed on commercially available equipment to facilitate an easy transition from the work done in the IDL to implementation of the procedure in a production operation.
- On-site demonstrations with portable equipment in four of the basic techniques.
- Interchange with NDE experts at CNDE for help in solving difficult problems.
- Early exposure to emerging equipment and methods.
- Unbiased information since IDL is a neutral source with nothing to sell and governed by the state ethics rules.

Benefits to CNDE include:

- Interaction with industry which keeps research relevant.
- The use of IDL equipment and reference materials for research projects on a non-interference basis.
- The employment of additional students as research assistants who receive valuable experience by working with industry.

#### **FUTURE PLANS**

As we enter our third year of operation, we will work to improve upon the services offered by the IDL. We are currently in the process of developing a General Inspection Technology Workshop. This four hour workshop will be geared toward individuals with a limited knowledge of NDE but will be valuable as a refresher course for those on the fringes of the field. It will present a solid introduction to penetrant, magnetic particle, ultrasonic, eddy current and x-ray inspections and touch on the various other NDE techniques. The goal of this workshop is to increase the participant's awareness of NDE and its ability to improve the quality of their product.

We will also continue to pay close attention to new research results. Many companies approach the IDL with problems which require state-of-the-art solutions. The need for a solution may not justify the expense of a large research program, but limited funds may be available for development work. The customer often feels the problem is of a sensitive or proprietary nature and is reluctant to advertise or widely discuss the matter outside of IDL staff. The challenge then is to match a customer's problem to the most promising advanced NDE technique or a mature research effort without divulging customer information. Currently, IDL staff try to make the matches by staying as informed as possible, reviewing published information and conducting literature searches. Ways to improve the odds of making a match are being considered.

## SUMMARY

The Iowa Demonstration Laboratory for NDE is well positioned within the NDE and technology transfer communities. Over the past 15 years, extensive research, education and outreach programs for NDE have been developed at Iowa State University. Strong relationships already exist with many national companies, particularly in the aviation and nuclear industries. The goal of the IDL is to provide a focal point for NDE research and technology transfer for small to medium sized companies, much as our parent organization, CNDE, has done for larger industries. In this way, the full technology transfer system is accessible to all segments of the manufacturing community with programs designed to meet their specific needs. With consumer demand for higher quality products growing, manufacturers are forced to explore ways to tighten their quality control standards. It is especially important that attention to quality start with the small manufacturer as many small companies serve as suppliers to the larger companies. The overall goal of this program is to raise the level of awareness and understanding about nondestructive evaluation in small to medium sized Iowa manufacturing businesses. Through education, demonstration and technical assistance, it is believed that manufacturers will implement NDE tools in their operations to improve product quality, reduce waste, and improve productivity through reduced rework. The approach we have taken to develop the current IDL program has been to solicit and heed the advice of industry. As we near the end of our second year of operation, we also approach the completion of a fully operational laboratory with capabilities in the five basic techniques. We have offered service and assistance to over 50 Iowa companies and provided numerous opportunities for information transfer. The IDL program has proven to be beneficial to both Iowa industry and Iowa State University.