

AUTOMATED RELAY TESTING AT DUQUESNE LIGHT

Presented by

EDWARD K. McGRANE

DUQUESNE LIGHT COMPANY

Presented before the
Energy Association of Pennsylvania
Electrical Equipment & Protection Committee
Spring Meeting at Reading, Pa.

April 19, 2001

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***By Edward K McGrane
Duquesne Light Company***

ABSTRACT

The concept of Automated Relay Testing for utilities has been around for approximately twenty years with the introduction of microprocessor based relay test sets. As with many other of these early products, the computer equipment required to interface with the test sets was expensive and the software was difficult to use. The widespread use of PC's (especially laptops) for testing relays was not utilized by most utilities until at least ten years later. Duquesne Light bought its first microprocessor based Relay Test Sets in the late 1980's, but did not buy its first Automated Relay Testing software until 1993.

OVERVIEW OF TRADITIONAL PROCESSES

Relay Settings

Traditionally Protection Engineers (PE) at Duquesne Light Company perform the process of determining the settings on a protective relay. Factors such as available fault current magnitudes, clearing time of Circuit Breakers, Transmission or Distribution Line Impedance, etc. are used to calculate the settings. The PE must also know the actual characteristics of each relay along with the setting parameters and the available CT and/or PT ratios. Also, the PE must coordinate each setting with the other relays or protection devices at the substation and/or on the line or bus. The settings are then written down by the PE and given to a Clerk Stenographer (CS) who types the **Setting Sheets** and returns them to the PE for signatures. After signatures, the setting sheets are given back to the CS who makes copies for distribution to the districts and files the original in the protection files. After the relay is set and tested in the field, a copy of the setting sheet is returned to Protection Engineering where the CS files the signed copy in the appropriate file. The entire process is very labor intensive and requires accurate records be kept to insure that each relay is properly set per the setting sheet and PE recommendations.

Relay Testing

Automatic Controlmen (Relay Technicians) perform testing of all Duquesne Light Company relays. Normally the crew is made up of a First Class and a Second Class Technician. Traditionally, the relays were tested manually using a combination of manual and microprocessor controlled Test Sets. Protective relays are tested when installed and on a routine basis every 3 years for the Transmission System and every 6 years for the Subtransmission and Distribution System. Auxiliary relays (or relays with no settings) are not included in the above Routine Testing program.

All substation equipment in Duquesne Light Company including transformers, breakers, meters, relays, etc. is entered in a relational database program called *Maximo*. This equipment database and work management program automatically schedules testing per predetermined intervals for all equipment, including protective relays. Auxiliary relays are tested when installed and every 12 years as part of an overall system check of the entire substation protection, including breakers, circuit switchers, relay systems, etc. Each Substation District must perform Routine Relay Testing, Troubleshooting and support new construction. Testing has traditionally been done manually using the Setting Sheets for each relay to determine the test values to be entered and writing down the results as manually observed on a Relay Test Report (RTR). The RTR is taken back to the District office where it is copied by a CS, filed and the original is sent back to Engineering where it must be filed by another CS.

Both the manual relay testing process, and setting sheet process, are very labor intensive and rely on field and office personnel to accurately test relays, record results and maintain files in several locations on each of the over 30,000 relays in the Duquesne Light system. With the corporate downsizing of recent years this was becoming more and more difficult.

Relay Equipment Database

In 1995 Duquesne Light Company started entering all relays into the recently purchased *Maximo* equipment database program. This was done when new relays were installed or when an existing relay was routinely tested. Although this program was very useful for keeping an inventory of all substation equipment, including relays, it was not designed to store test data. There are fields within *Maximo* to indicate if the relay passed or failed a scheduled test, however actual test values had to be written down on the RTR forms and manually filed with the setting sheet for each relay.

INITIAL AUTOMATIC RELAY TEST PROGRAM

In 1993 Duquesne Light Company purchased the Doble *ProTest* software package for Automated Relay Testing. This package was used for specialized testing of various relays that could not be easily tested using more traditional methods. This included a test performed in 1995 using satellite synced Doble Test sets to test and cut-in a scheme consisting of three terminals of General Electric DLS3 Current Differential relays protecting the Collier-BI-Carson 345 kV transmission line. Because of the unusual configuration of this line manual-testing methods could not be employed to simulate various “internal” and “external” faults scenarios. The required end to end tests could only be performed using Test Sets that could be initialized simultaneously at remote and local locations within a millisecond of each other.

This application demonstrated the value of Automated Relay Testing, however because of the shortage of both Doble Test Sets and Laptop PCs at Duquesne Light and union issues about who could operate the PCs the Automated Relay Testing (ART) program never gained wide acceptance.

In the late 1990's it was recognized that the Automated Relay Testing program needed to be more widely used for testing because the backlog of relays requiring routine testing was increasing according to the *Maximo* program. Because of downsizing, the number of relay technicians was decreasing while the number relays requiring testing was increasing. Also, most of the newer relays being purchased were microprocessor based and most required PCs to program in the settings. These multifunction relays, many with in excess of 100 settings, required time consuming test procedures if tested manually. Engineers, who were also being downsized, traditionally wrote these procedures. Therefore, the time was right to pursue Automated Relay Testing for as many relays as possible.

PRESENT AUTOMATIC RELAY TESTING PROGRAM

In 1999 DLCo purchased a copy of *UltraTest* from Universal Power Products (UPP) (what is today ENOSERV RTS) for evaluation. This program, like Doble *ProTest*, used an existing library of relay test procedures provided by the manufacturer for a number of commonly used relays. The *UltraTest (RTS)* software enables the user the capability to modify the software by writing additional program code or macros for specific groups of relays. The user can also create their own library and add or delete macros from other routines to customize the test routines for a specific group of relays. Since the routines reside in the users own library, all relays are automatically supplied with the latest revision prior to testing. This makes the relay test database management much easier. The *UltraTest (RTS)* software also has drivers to run various models of Test Sets from different manufacturers including Doble, which is used

by Duquesne Light Company. Results of the evaluation were promising and it was decided that the UPP *UltraTest (RTS)* program would be the Duquesne Light Company standard for Automated Relay Testing.

A one-week *UltraTest (RTS)* training program from UPP for both engineers & technicians was held at Duquesne Light in late 1999. From this group, a Project Team was formed and two technicians were chosen as ART Developers.

ART Steering Committee & Project Team

In early 2000 an ART Steering Committee and Project Team were established to implement ART and to automate the relay settings process. The Steering Committee consisted of the Manager of Engineering, Manager of New Business Solutions, and the supervising engineers from substation operating districts and an engineer from New Business Solutions for IT administration. The ART Project Team consisted of a protection engineer, maintenance engineer, IT engineer for administration of the ART database and two relay technicians. It was decided that relay technicians could better be utilized if they were involved from the start with the program. This included letting the relay technicians, the ultimate users of the program, be the ones who actually write code and develop the test libraries. This would ensure better “buy-in” of the program from the technicians and relieve the engineers from having to develop test procedures on a day to day basis.

ART Developers

Presently there are two First Class Relay Technicians working as full time ART Developers to write *UltraTest (RTS)* routines for Duquesne Light Company relays. The developers work out of Carson Substation, which is centrally located within the Duquesne Light Company system. This location was chosen so that the technicians could work full time at one location without the need to schedule a special lab or room that could handle all of the test equipment. Carson is also both a Transmission and Distribution substation and had a wide variety of relays on-site that the Developers could use to build the library of test routines. As other relay routines needed to be developed, the relays were either taken from stock or newly purchased non-stock relays were sent to Carson SS.

Another advantage to using Carson Substation is that the Developers have used it as a training center for teaching other Relay Technicians how to use the *UltraTest (RTS)* library routines they have developed. This has enabled the program to gain rapid acceptance and has relieved the burden on engineering to write code and provide training. The engineers still provide guidance and final approval of

routines, however the day to day development work is with the ultimate users. This has eliminated the condescending structure of the original Automated Relay Testing initiative and is probably the main reason that this program has been so successful.

ART Routines

One of the early problems to overcome was how to develop ART Routines for over 30,000 individual protective relays (375 different types) on the Duquesne Light Company system. The relay test routines from the manufacturer covered many of the more common relays used by utilities, like time overcurrent and distance relays, but these routines were generic in nature. Duquesne Light Company, like most other utilities, had specific testing procedures, which had been developed over many years and were reluctant to throw out these routines. Because of the ability to revise or write new code and macros in the *UltraTest (RTS)* program for any routine, or even to create a new library routine, this problem was overcome.

To guide in the development of routines, all of the existing written test procedures were reviewed. Relay Template Standards were made to emulate the *UltraTest (RTS)* screen and the data needed to populate this screen. This included the **Nameplate** screen, which includes the User Defined Fields, Settings, and Figured Settings needed to test the relay. Attached are copies of the **CO** and **KD-10** Relay Templates which were used to define the above fields. These Templates were drafted by engineering and used during monthly meetings of the Project Team to define what needed to be included in the development of the Library Routines.

For the 375 types of relays on the system, a total of 68 Library Routines have been developed as of March 31, 2001 which cover 25,403 of the 30,938 or 82% of the total relay population.

Maximo Interface

The *Maximo* equipment database fields for all relays are presently used to automatically “populate” the *UltraTest (RTS)* **Nameplate** fields. This assures that information such as Equipment Number, Substation Name, Location, Relay Model Number, Circuit Name, etc. are all identical to the *Maximo* database when the Relay Technicians tests an existing relay in the field. Since this information is provided from *Maximo* it eliminates mistakes such as “typos” or differences in the way people enter the “same data” that can make database management a real nightmare. If testing a new relay, the technician first enters the necessary equipment information in *Maximo* to

establish a unique Equipment Number and all other required data. After the relay is successfully entered in the *Maximo* database, the User Defined data can then be downloaded to *UltraTest (RTS)* and the relay can be tested using in the normal manner.

AUTOMATED RELAY SETTING PROGRAM

In 2000 Duquesne Light Company purchased from UPP the *PowerBase* program to automate the relay setting process. Presently development work is proceeding by Duquesne Light Company engineering and UPP to implement the *PowerBase* program and to tie it into *UltraTest (RTS)*. This will enable DLCo to eliminate the labor intensive “paper system” for relay settings. Settings for each relay will reside on the ART Server and be entered in *PowerBase* by the Protection Engineer as “pending” settings. These settings can then be downloaded in the District onto a laptop PC to test the relay. After testing the relay will automatically labeled as “Tested” and the results will be uploaded by the technician to the LAN and be immediately available and archived to the *PowerBase* database which resides on the ART Server.

The 375 types of relays on the Duquesne Light Company system were broken down into **Tables** containing relays with similar operating characteristics and testing criteria. From these Tables, specific **Views** are developed for each type of relay. Each Table contains a master list of all of the elements for all of the relays covered, while the View contains only the specific elements needed for a specific type of relay (see attachments). Using these criteria it is estimated that approximately 40 Tables will cover 90% of all relays at Duquesne Light Company. Microprocessor type relays, because of their uniqueness and numerous settings will probably have a much smaller number of Views per Table. Some of these relays may have only one Table with one View.

CONCLUSION

The Automated Relay Testing program implemented at Duquesne Light Company in 1999 and has been very successful. For the 375 types of relays on the system, a total of 68 Library Routines have been developed which cover 25,403 of the 30,938 or 82% of the total relay population. One of the main reasons for the success of the program was the decision to let the relay technicians, the ultimate users of the program, have the responsibility of writing the test routines. Average time savings per relay tested have been approximately 10% for a simple electromechanical relay to 80% for a microprocessor type relay with multiple settings. Also, the accuracy of the automated testing is greatly improved since all tests are run with the same Library Routine. The Library Routines and testing results are also immediately available on the ART Server via the LAN, which will ultimately eliminate the need for the old paper system. When the *PowerBase* automated setting program is fully implemented additional savings and accuracy will be realized.