1983 PERSPECTIVES

PTI's analytical consulting services remained in strong demand during 1983, despite curtailment in planning activity on the part of many utilities. As systems are made to operate closer to their limits, there was more emphasis than ever on the detailed modeling of system components and their verification by field tests. PTI also began its first system-wide transmission uprating study, considering both mechanical and electrical arguments — a program that we feel more utilities will find worthwhile in the next several years. Our role in courses continues to grow, the year's most notable success being the video tape course for Power System Operators. This Newsletter announces another such course — this one for Distribution System Operators.

In software products the past year saw the list of PSS/E users grow to 76 worldwide, and the program's capabilities continue to expand. Meanwhile, UNISYSTEM, PTI's software for plant simulation, emerged as another of the Company's strong software offerings. A broadening of the range in computers on which PTI software is applicable continued, IBM and Appollo being the most significant additions to the list during the year.

The second of two Transient Network Analyzers was shipped to China early in 1983, and another for Comision Federal de Electricidad in Mexico will be shipped early in 1984. Several of PTI's retrofit excitation system stabilizers were being readied for shipment late in the year. We also designed, built and installed a very sophisticated load shedding system for use by industrial companies with significant levels of in-house generation.

The utility industry has changed dramatically since PTI's organization in 1969. Over those years, all of us at PTI have worked to adapt the Company to the changing needs of the industry. We sincerely appreciate the confidence clients have shown in PTI as new services and products are introduced and we are committed to maintain the highest standards which will continue to warrant that confidence.

M.R. Stambach, Unit Manager

In November, 1983, PTI began production of a new video training program entitled, "Distribution System Operation". It is designed to assist in the overall training of personnel responsible for operating an electric utility's distribution system. The twenty-tape program is being jointly produced with Leighton & Kidd, Ltd., Consulting Engineers in Toronto, Canada. Utility participation in the production of the course will assure balance between theoretical and practical aspects of the presentation. PTI has enlisted the technical assistance of the Niagara Mohawk Power Corporation in the production of the video program.

The video course is aimed at the technician level and stresses physical concepts, analogies, and practical procedures rather than involved mathematical relationships. The program begins with a review of electrical theory and fundamentals and then provides an overview of the bulk power system, including discussions of power generation and transmission. Load characteristics, system interconnections, economic operation, and frequency and voltage control are introduced so that the participants will understand how these subjects affect operation of the distribution system.

The distribution system, its equipment and operating procedures are then examined in detail including:

- Distribution system layout and equipment; overhead and underground primary and secondary systems.
- Function and basic operating characteristics of distribution equipment, including substation and distribution transformers, switching and isolating devices and protection and voltage control equipment.
- Normal and emergency operation, communication, control and automation, service interruptions and the operator's role.

The Distribution Operation video program is similar in format to PTI's recently completed video training program, "Power System Operation", also a joint venture with Leighton & Kidd (PTI Newsletter, January, 1982). That program is now being used by over 70 major electric utilities and power pools worldwide.

Like the System Operators course, the Distribution Operation course is designed either for self-paced learning or for use with an instructor who can tailor the content to the participants' own system and practices. A set of student workbooks and an instructor guide is provided with each videotape. The workbooks are keyed to the tapes, which are divided into small, manageable "segments". Questions pertaining to each segment of the tape are included in the workbook. The participant may then receive immediate feedback by checking the complete set of answers provided in the back of the workbook.

Utilities have found these video training courses to be a very effective way of conveying complex technical ideas to non-engineering staff through an entire array of visual aids, including still and motion pictures and animation. Utility companies using the video course find that it eases the demand on their own instructional modes and retains a much higher level of interest among the participants than does a conventional lecture program.
HPO — WHAT ROLE IN TRANSMISSION NETWORKS?

Lionel O. Barthold, President

The first issue of the PTI Newsletter (June, 1975) carried a rather tentative article on High Phase Order (HPO) transmission. It makes interesting reading in light of the changes seen by the industry and the progress made in that technology in this past eight-year period.

As 1983's economic recovery begins to be felt, one can make a pretty good case for the fact that constraints in transmission capacity will be the next major problem for U.S. power systems. Transfer limits are already of concern in some parts of the U.S. and the environmental objection to new construction and to UHV does not appear to be abating. In fact, the prospect of commissioning 800 kV even where the towers are already in place is poor. Furthermore, the industry has probably not seen the last change of signals as to what constitutes the most appropriate primary fuel sources and, therefore, the most favored generation sites. Redirections of that sort could be compounded by a resurgence in load growth which, at least on a regional basis, could outstrip generation capacity, recognizing how long it takes to add to that capacity.

Furthermore, high fuel costs and other incentives for flexibility in dispatch has also increased the importance of capability.

These factors certainly prompt one to look at existing rights-of-way as a rather precious asset and to seek means for their more efficient utilization. That has been the motivation for quite a number of transmission line uprating projects — uprating either in voltage class or conductor. However, PTI's research on HPO feasibility suggests that a far greater transmission uprating capability is possible through rebuilding programs within existing right-of-way boundaries and environmental impact limits.

The initial assumption in HPO research was that a six-phase circuit at one voltage might be economically competitive with a three-phase line at the next higher voltage. Twelve phase was assumed a somewhat academic extension of the concept. Economic studies now show that six-phase is clearly competitive with a higher voltage circuit, but that 12-phase construction should also be considered very seriously. Most EHV six-phase circuits would require a two-conductor bundle but that bundle can be separated into separate phases to make a 12-phase line within the same overall tower dimensions. The result is a 50% increase in surge impedance loading (SIL). Either configuration can be integrated into a three-phase system by means of an autotransformer, both are straightforward relay applications, and neither represents much more than a reapplication of existing and well-established technology.

To appreciate the increase in right-of-way transmission density realizable with HPO, two examples are useful. Figure 1 shows a typical 800 kV right-of-way and conductor configuration, which if used at 800 kV would provide an SIL of about 2400 MW. The same figure shows placement of two 317 kV, 12-phase circuits. 317-kV is the line-to-ground voltage of a normal 500 kV 3-phase line. The surge impedance loading of the latter two circuits is 5500 MW, having the additional advantage of double-circuit reliability. The 12-phase configuration has a slightly lower radio noise level at the right-of-way edge, a lower electric field at ground level, and virtually no audible noise.

Even more dramatic improvements can be made on lower voltage rights-of-way. Figure 2 shows a typical 230 kV ROW which will support a single circuit 317 kV, 12-phase line. Again, audible noise is extremely low, and both RI and electric fields are within generally accepted limits. In this case, SIL of the right-of-way is increased from about 280 MW to 2800 MW, a capability normally associated with 800 kV. Thus, 230 kV rights-of-way can be used to achieve loading equivalent to the highest voltage now in use in the U.S.

While SIL has little to do with actual transfer capacity, the latter being largely system-dependent, lines of equal SIL are generally equivalent to one another from a system standpoint. Thus, SIL does provide an index for comparing circuit alternatives.

The foregoing comparison rests on the assumption that power transfer is reactance limited. Yet the argument for HPO is not necessarily diminished in cases which are thermally limited. Where thermal limits are imposed by maximum ratings of commercially available circuit breakers, HPO divides the problem into more current paths, effectively allowing “paralleling” of circuit breakers.

Apart from the test lines at PTI's Saratoga site, no one has yet built an HPO line. The number of utilities actively considering this move increases each year, however, and if the pressure for increased transmission capacity continues, it's a technology that bears watching. Certainly if the transfer levels associated with UHV find application, HPO is likely to be a tough competitor.
STEAM TURBINE EFFICIENCY ASSESSMENTS CAN PROVIDE VALUABLE RESULTS

R. E. Brandon, Senior Engineer

PTI's turbine inspection services have grown steadily over the past year, reflecting the utility industry's interest in enhancing plant efficiency and extending plant life. Maximizing steam turbine efficiency and capacity is a challenging matter. Excessive leakage, solid particle erosion, thermal distortion, chemical deposits and internal damage all combine to degrade the steam path of these sophisticated machines. No other power plant component is so sensitive or has such direct impact on plant performance.

Turbine components are normally inspected on three to six year intervals, making an accurate evaluation and an exacting repair essential at that time. Complete performance assessments, when such units are open for inspection, have provided valuable improvements in sustained performance.

Such assessments normally include the following:

* Appraisal of leakage controls — packing and spillstrips

This critical part of the work should determine seal wear patterns, both axial and circumferential, magnitude of leakage flow, loss in output and efficiency (corrected for recovery by following stages), achievable improvement resulting from repair, probable causes of observed conditions such as thermal distortion, shaft bowing, water induction, etc., and most important, improved operating techniques to lower the probability of recurrence. Unless positive steps are taken, such problems normally repeat themselves with devastating frequency—usually on the first restart following expensive seal repair.

* Appraisal of sneak leakage paths

Turbines employ a wide variety of seals, including piston rings, bolted joints, access covers, expansion joints, seal edges and emergency valves. Each is a potential source of leaks which must be carefully examined for tell-tale signs of unwanted flow—deposit patterns, erosion marks, build-up of local oxide layers and permanent stretching or distortion. Such sneak leakage is normally not a consideration of reliability and will be only repaired if observed and properly evaluated by those concerned with thermal performance.

* Appraisal of solid particle erosion

This very destructive problem usually attacks the first turbine stage and the first reheater stage, although damage will frequently persist to a few subsequent stages as well. The assessment must answer several related questions:

- Has the performance monitoring and diagnosis properly predicted the observed level of damage?
- Will the planned repair procedures assure performance recovery?
- Will the rate of erosion damage be more severe during the next operating period?
- Can revised operating techniques such as variable pressure or full arc admission lessen future erosion problems?
- Can monitoring programs be enhanced to recognize an appropriate limit where a severe damage forced outage may be imminent?

* Appraisal of Internal Damage

Such problems result from several sources such as the entry of foreign material (weld beads for example) or the breakage of an internal turbine component. The appearance and probable threat to further damage must be thoroughly documented. Monitoring techniques should be studied to determine whether they properly predicted the level of damage or to identify improved techniques that would. Planned repair procedures should be examined. Probable long term losses caused by compromises in profile roughness and distortion should be calculated. Assistance should be provided regarding justification for replacement where the losses will be significant.

* Appraisal of Steam Path Deposits

Deposits are less of a problem than in the past. Still, occasional severe losses are encountered. Only a few mils deposit thickness can cause several percent loss in stage output. The deposits distort profiles, increase roughness and change pressure, energy and velocity distributions.

Good photographic records and conservative calculation of probable loss is essential. Probable causes of chemical deposits should be probed for possible improvement (or the threat of future worsening). These might include malfunctions of chemical injection equipment, excessive reheat desuperheating flow or occasional condenser leaks.

Significant findings during recent turbine assessments include the following:

- Thermal distortion is an important factor leading to damage of packings and spillstrips. Improved starting techniques can reduce this danger.
- Repairs to solid particle erosion-damaged components do not recover original performance levels. Improved techniques can be specified to lessen this serious loss.
- Analytical techniques are available to better predict internal turbine conditions from performance monitoring data.
- Improved analytical techniques for determining local losses from observed physical conditions are available.

A combination of diagnosis, using turbine monitoring data with full performance appraisal during inspection periods will greatly enhance the understanding of existing losses and the probability of improved future performance. Benefits of 1 to 2% can be expected.

PTI's experience with turbine inspections suggests that utilities would often do well to use the inspection opportunity to greater advantage as a way to enhance turbine efficiency, thus adding to the acknowledged benefits in improved reliability and longevity.

FIRST MICROPROCESSOR-BASED POWER SYSTEM STABILIZER SCHEDULED FOR SHIPMENT

Newsletter issue #27 of October, 1981 described a new microprocessor based stabilizer under development at PTI. This novel implementation of stabilization uses microprocessor to modulate the voltage feedback from PT's to the AVR through solid-state switching of taps in an autotransformer inserted between the PT's and AVR (fig. 1). The first three commercial grade production units shown in the photograph on page 4 are ready for installation on generating units of Georgia Power, Consumers Power and Hydro Quebec, utilities which co-sponsored with PTI the realization on the new concept.
Unique features of the design are:

- The device provides the AVR with a signal of the same type as the normal 120 vac feedback which is universally used on all automatic voltage regulators. Accordingly, it can be used universally with any type or vintage of excitation system.
- All required intelligence for stabilization is derived from machine terminal voltage and current signals as provided from PT's and CT's without need for transducers.
- Computations are performed by digital techniques in a microprocessor. Adjustments are digital and thus not subject to drift or calibration problems. Logic is provided for self-checking and for automatic bypassing of the stabilizing function in case of malfunction detection.
- The modulating device is rugged, simple and reliable involving merely tap changing of an autotransformer with solid state optically-isolated switching.