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Control System Retrofit Guidelines Update

Review of Original Report and Recommendations for Updating

1010263

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Technical Update, December 2005

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ABSTRACT

In 1992, EPRI published a 3-volume report entitled "Control System Retrofit Guidelines," TR-100343. Since that time there have been many changes in control system technology and in the power industry. Most plants that were originally built with analog control systems have been upgraded to digital systems and many plants today were originally constructed with digital control systems. Not many analog-to-digital control retrofits are still being done. However, many early digital systems that were installed in the late 1980's and early 1990's are now obsolete and in need of upgrading. This prompted some EPRI members to request an update to the Control System Retrofit Guidelines to incorporate digital-to-digital upgrades and any other major technology changes since 1992. This report reviews the contents of the original report and identifies topics where additions or revisions are necessary. Recommendations are also provided on the best methodology of updating the report. The actual production of an updated version of the report will be done in future years

CONTENTS

1
INTRODUCTION

In 1992, EPRI published a 3-volume report entitled “Control System Retrofit Guidelines,” TR-100343. The report was very useful for member companies considering a control system upgrade and provided information on all aspects of modernizing a fossil plant control system. Now, thirteen years after the initial report was published, the industry and control system technology have changed considerably. Most plants that were originally built with analog control systems have been upgraded to digital systems and many plants today were originally constructed with digital control systems. The exact percentage of plants with digital control systems is not known, but is believed to be more than 80%. As a result of this, not many analog-to-digital control retrofits are still being done. However, because of the rapid advances in digital technology, the effective life of a digital control system is much shorter than the analog systems they replaced. Many early digital systems that were installed in the late 1980’s and early 1990’s are now obsolete and in need of upgrading. This prompted some EPRI members to request an update to the Control System Retrofit Guidelines to incorporate digital-to-digital upgrades and any other major technology changes since 1992. This report reviews the contents of the original report and identifies topics where additions or revisions are necessary. Recommendations are also provided on the best methodology of updating the report. The actual production of an updated version of the report will be done in future years

2 ORIGINAL REPORT OVERVIEW

The original Control System Retrofit Guidelines report was produced in 3 Volumes. Volume 1, Methodology and Cost Justification provides information on how to approach a retrofit project and how to determine whether the benefits will make the project worthwhile. Volume 2, Technical Assessment describes the functional requirements of digital control systems for power plants and provides detailed information about several commercial systems. Volume 3, Cast Studies documents real world experiences of several control system retrofit projects. Although the report is out of print, EPRI recently scanned the original version of the report and it is now available as three downloadable portable document files (PDF), one file for each volume.

This three volume report is a very comprehensive document and provides power company personnel with a single point reference book about control system retrofits. The report was prepared by two large architect/engineer firms with considerable experience in the power industry control retrofit business. Volume 1 was prepared by Sargent & Lundy and Volume 2 was prepared by Black and Veatch. Volume 3 was a joint effort of both firms along with several power companies.

The report covers three main topics. The first is developing and managing a control retrofit project. The second is the technology of digital control system including much vendor specific material. The third is a series of case studies of control retrofit projects that provide valuable real world experiences. The parts of the report that describe project development, justification, and management have aged quite well in the 13 years since it was first published. Project management is still project management.

The sections that deal with control system technology have not fared as well. In 1992, digital control systems were a relatively "new" technology and the many in the industry was still quite cautious about their application to power plants. Since then digital control has become ubiquitous in the industry and all concerns about it for power plant application have disappeared.

The case studies are also quite dated. It is very interesting to read them and see how far the industry has come in the past 13 years in its application of digital technology. What was viewed as revolutionary in 1992 is common practice today. The biggest change may be in the acceptance of video display technology for the operator interface. Many early digital retrofits retained some of the old operator interface but today everything is all video displays.

Although the overall report has aged well, there are several aspects of control system retrofits that have changed significantly in the past 13 years and these must be considered in an updated report. First, the power industry has undergone many changes including deregulation and competition, increased environmental controls, and many mergers and acquisitions. Second, the technology of the digital control systems has continued to evolve rapidly, particularly the communications networks which form the backbone of all modern control systems. Third, digital control is no longer a "new" technology to be cautious about, but is universally accepted as a vital component in all plant operations.

In this section, the topics in the report that need to be revised or added are discussed. Some perspective on why the change or addition is necessary is provided. No attempt has been made to draft the changes or additions, but all affected topics have been identified.

A detailed review of each section of the report has been done and is included in Appendix A.

3
RECOMMENDED REVISIONS TO REPORT

Revision Methodology

There are two approaches that could be used to produce a new version of the document. One option would be to produce an updated version of the entire document and retain the same basic structure of the current document. If topics did not need revision they would still be included in the new version unchanged. Topics needing to be revised or added would be incorporated into the new version in the appropriate location. This would result in a new document that would completely standalone.

The second option would be to prepare a new document which only contained the new and revised information but did not incorporate any of the unchanged information in the old report. In this case the new report would not standalone, but would have to be used with the old report to provide all the information about control retrofits.

The cost to produce a new version of the report is also a major consideration. While the exact cost to produce the original report is not known, it likely was around $200-300K. With the current resources of the I&C and Automation Program, a project of that magnitude is not possible in a single year. Therefore the scope of the work may need to be reduced or the work may need to be performed over more than one year.

The option to prepare an entirely new version of the report is the recommended approach for this project. While this might cost somewhat more than the other option, having a new standalone document will likely be worth the extra cost. No cost estimates for either option have been developed.

Topics for Revision or Addition

In this section, topics related to control system retrofits that are discussed in the guidelines but need revision or are not discussed at all and should be added, are described. A brief discussion of why each topic should be revised or added is provided.

Digital-to-Digital Upgrades

In 1992, all control system retrofits were analog-to-digital conversions. But 13 years later, many first generation digital control systems are obsolete and are being replaced with new digital systems. Digital-to-digital upgrades share many project commonalities with analog-to-digital upgrades, but the technical aspects are considerably different.

In many analog-to-digital upgrades, a pneumatic system was being replaced with a digital system. These type of projects involved significant field work because all new electronic field sensors and the associated wiring had to be installed. In addition, most control rooms required major modifications to convert to video display technology in place of the old hardwired panels. Training of both operators and technicians is another area where an analog-to-digital upgrade necessitated much more work than a digital-to-digital upgrade. Converting operators from a hard panel type interface to a video interface is a major task and many companies bought training simulators specifically to improve the transition. Technicians also had to be introduced to the new digital technology and learn new operating systems, troubleshooting techniques, and data handling methods.

For a digital-to-digital upgrade today, the issues mentioned above will likely be secondary considerations. The only field work required will be when the scope of the new system is expanded over the original system. This will probably happen quite often because the industry experience has been so positive and plants are generally looking to increase their levels of automation over what they had in 1990. Even with this added scope, the amount of field work will be much less than the typical analog-to-digital retrofit. The control room will already be set up for video display systems although there may be a desire to revise the design based on first generation lessons learned. Minimal operator training should be necessary and technicians should be able to adapt to a new digital system readily.

The primary considerations in a digital-to-digital retrofit will vary from company to company but will likely include cost, flexibility, and interfacing with outside systems. Cost is always an important issue but might be more important today than 13 years ago because digital control systems are almost considered a commodity today. Many users still have a preference for one system over another, but all the major systems are very capable as shown by their customer lists.

Control system flexibility has always been an important feature of digital control technology, but power companies today are continually upgrading their plants to meet regulatory and market needs. A flexible control system platform should be able to adapt to these changes without major system revisions.

One of the major changes for digital control system over the past 13 years has been the acceptance of the DCS as the central control and human interface platform for the entire plant. In this role, the DCS has to be capable of sharing information with a diverse group of external control systems. Examples include turbine controls system, and a myriad of programmable logic controller (PLC) systems for functions like sootblowing, ash handling, water treatment, and many more. In addition the DCS is expected to interface with many non-control plant data systems such as data archive systems and maintenance management systems. The DCS and its operator interface have become the central hub for all plant control. Issues specific to the human-machine interface and interfacing with non-control data system will be discussed in other sections below.

In the coming years most control retrofits will be digital-to-digital and given the rather short life span of digital technology, there will be many of them. While most of the project issues are the same for digital-to-digital and analog-to-digital upgrades, much of the technical issues are different. For this reason, this topic should be thoroughly addressed in the new version of the guidelines.

Human Machine Interface (HMI)

When analog control systems were first replaced with digital systems, the human machine interface usually consisted of a combination of some hard panel control and some video display control. It was typical to retain the hard manual automatic control stations for interfacing with individual loops. Also, it was common to retain at least some of the hard annunciator panels. These decisions were made because users were unsure of the video display interfaces reliability and usability and wanted a backup system just in case. The result was a functional but less than optimal operator interface system.

Thirteen years later, video technology has improved tremendously and there is no reluctance to use it exclusively for the human machine interface system. Little or no hard panel controls are provided. This enables the control room design to be streamlined considerably and still provide a better interface. Other changes include the use of larger numbers of displays and the use of large screen displays for plant mimics and overview graphics. Overall the human-machine interface has been significantly improved and these improvements need to be discussed in the new version of the report.

Interfacing of Control and Plant Networks

In 1992, some pioneers were considering the possibilities of interfacing the control system network with the plant business network primarily to export operational data to engineers and managers. While it could be done, it was rarely attempted. The main reason was that the DCS used a proprietary network and a special gateway was needed to communicate with the plant network. This complicated the process and increased its cost to the extent that most companies thought it was not worth the effort. Throughout the 1990s, networking technology matured rapidly and became a part of everyday life. A change also occurred in the control systems.

Vendors began to use commercial workstations for operator interface machines and application processors on the DCS. These commercial machines had built-in Ethernet networking and also had a custom connection to the DCS network. This suddenly made it trivially easy to connect the control network and the plant network to the workstation and use it as a bridge between the two worlds. Many plants did this without any fanfare and were able to share files and graphics with outside computers. It wasn't until the plant networks became connected to the internet that problems started to arise. The main issue was security and the risk associated with a hacker gaining unauthorized access to the control system via the internet. This forced companies to think much more carefully about how their control systems were connected to the plant network. Most believed that the connection was valuable, so firewalls were installed to prevent intrusion. However, it turns out that network security is a very complicated issue and requires considerable effort to do well. The National Electric Reliability Council has even gotten involved in writing standards for security because of concerns about the energy infrastructure and terrorism.

The whole area of connecting the control network to the plant network was not addressed in the 1992 report but is now very important and must be included in the new version.

Digital Communication with Field Devices

Modern control systems connect to hundreds of field devices and until recently each field device had its own dedicated connection to the DCS. In the late 1980s when process instrumentation began converting to microprocessor technology, instrument manufacturers conceived of the idea of a digital fieldbus. Fieldbus is just a specialized network for instrumentation and other field devices to communicate with the digital control system. Since almost all field devices are now digital internally, it makes sense to send their data to the DCS digitally also. This eliminates analog-to-digital converters at both ends and improves accuracy. It also enables field devices to communicate additional information besides the process value. Some proprietary systems were developed quickly but it was apparent that an open standard would be needed to make the technology commercially successful. Unfortunately it took many years for a standard to be finalized but eventually it happened. Since that time the acceptance of fieldbus technology has been lethargic in the power industry but recently interest appears to be increasing. Fieldbus technology has broader implications than just as a replacement for the 4-20 mA standard. Fieldbus technology enables a rethinking of the structure of the digital control system. With digital field devices, it is possible to put the lowest level of control in the field instead of in the main DCS control processor. The debate about whether this is the right thing to do on power plants has not been settled yet but the option is there for those who choose to use it.

Fieldbus technology is still not widely used in power plants but usage is increasing as the technology matures and users become more familiar with it. The new version of the guidelines will discuss fieldbus technologies and provide recommendations on where the application of the technology makes sense for power plants.

DCS Integration with Other Control Systems

As mentioned above, the DCS has evolved into the central hub of all plant controls. In 1992 most plant control systems consisted of several distinct sub-systems for boiler control, turbine control, burner management, and data acquisition. Today the trend is to do more and more control functions directly in the DCS platform. However there are still other plant control systems, usually PLC-based, that many users want to be controlled through the DCS human machine interface. DCS vendors all provide some capabilities for doing this but the area still causes problems occasionally. In addition, new communication protocols and methods are continuously being developed and some are being used in power plants.

Integration of the DCS with other control systems was not a major issue in 1992 but it is today and as a result will be included in the revised report.

Off Platform Data Archiving

One of the attractive features of digital control systems in the early 1990s was their ability to store a large amount of process data on-line for later retrieval and analysis. A "large amount of data" in 1990 is not quite the same thing as a "large amount of data" today, but the old systems were certainly a huge improvement over strip charts. As the data archiving function became more important and applicable to more than just the DCS, specialty vendors emerged who provided high performance data archiving systems. These off platform archives have become quite popular in the industry today but were practically non-existent in 1990. They have broadened their functionality to provide data analysis and viewing tools. They often also serve as a bridge for data between the control and non-control systems. They will be discussed in the new report.

Optimization and Advanced Control Systems

The same networking technology which allowed the DCS to be connected to the plant network, also allowed other higher level control systems to interface with the DCS. The first and still most common application of this type is a NOx and heat rate optimization system. These systems were sometimes implemented in a separate computer which was then networked to the DCS or they were implemented on one of the native DCS workstations. The same situation exists with several advanced control products such as model predictive control and robust control. Interfacing these advanced applications to the boiler control system was a very involved process before the modern digital control system. Now it is very simple and this means that these types of applications should be given serious consideration when evaluating performance improvement options.

Lifecycle Software and Hardware Maintenance

One downside to modern digital control systems is their relatively short life cycles. Digital technology, such as microprocessors, memory chips, and most semiconductor chips, is continually evolving at such a rapid pace that systems built with these components become unsupportable in about 10 years. This does not mean that the entire DCS must be upgraded every 10 years. It does mean that some components of the system need to be upgraded that often. Usually the newer device is backwardly compatible to some extent and the impact on the system is not severe. But every so often, the upgrading of a single component triggers a cascade effect on other hardware and software in the system. Vendors typically issue software upgrades every year or two. Sometimes the software upgrades require hardware upgrades also. Users have to decide whether to keep up with all the software and hardware upgrades as they are issued or just stick with the original versions for their system as long as they can. There are also maintenance or bug fixes that should be applied as soon as they are shown to be effective. The topic of lifecycle management of the plant control system has become a large issue recently and will be explored in the revised report.

Cost Estimates

The original report included considerable cost estimate data for several different types of plants and projects. It would be very useful to provide similar data for recent project that include digital-to-digital upgrades, plant-wide upgrades, DCS to plant network integration, and other new project scopes. Users may be less willing to share cost data today than they were 13 years ago because of concerns about competition.

System Technical Information

Volume 2 of the original report was devoted to technical information about digital control systems. Part of the information was desired functionality but much of the information was specific to the various commercial control systems. The vendor specific information does not need to be updated in the new version of the report. The features of each commercial system change so often that any information published in the report would likely be out of date within a year. Also, the vendors are quite willing to provide this type of information to any customer who requests it.

Case Studies

The original report contains many case studies prepared by power companies and designers that provide real world experiences with control system retrofits. Technology users always appreciate hearing about other users' experiences directly rather than filtered through vendors. The revised version of the report should provide similar case studies but rather than discussing analog-to-digital upgrades, they should discuss digital-to-digital upgrades and the other new technologies described above.

4
CONCLUSION

The Control System Retrofit Guidelines report was a useful document for power plant control system users when it was first published in 1992. Several EPRI members have recently expressed interest in updating the report to include several new topics, such as digital-to-digital retrofits. This technical update report has reviewed the content of the original report in detail and provided recommendations on topics that should be added or revised. In addition, it is recommended that an entirely new version of the report be produced rather than just publishing those sections that are revised. This will provide a standalone document that will be a useful reference for power industry managers, engineers and technicians for years to come.

A

DETAILED REVIEW OF ORIGINAL REPORT

Review of Volume 1

Vol. 1, Section 1, Project Identification

1.1 Identification of Problems and Resolutions – OK

1.1.1 Performance test

- OK, but poor performance may not be the motivation for digital-to-digital upgrades.

1.2 Project goals

- OK, except for requirement of 15 system life and reference to hard M/A stations. Modern systems are not likely to have 15 year life without some upgrades along the way. Paper by Baptiste from 15th Joint ISA POWID/EPRI Control and Instrumentation Conference (2005) provided a good list of current project goals as noted below.
  - All operator functions through CRT
  - Easy configuration of graphics and operator displays
  - Real time and historical trending
  - Historical archive of all process data
  - Process alarming
  - Maintenance requirements
    - Simple design
    - Easy to troubleshoot
    - Robust hardware
    - Uniform modular hardware
    - Single vendor
    - No single point of failure
    - Reduced O&M costs

1.3 Preliminary Conceptual Design and Cost Estimates - OK

1.3.1 Assessment of Existing Facility

- Needs updating to address:
- What is the state of the existing DCS?
- What will be the scope of the upgrade?
- Will there be new field equipment; are either the wireless or fieldbus technologies applicable to meet the upgrade requirements?

1.3.2 Field Devices

- Needs updating to address smart field devices, remote I/O, and fieldbus issues.

1.3.3 Conceptual Design Alternatives

- Needs updating to include new design alternatives.
- Less emphasis on individual functions such as boiler control, burner management, turbine control, data acquisition, etc. More emphasis on integrated system.
- Here the DCS to DCS migration issues must be addressed including impact on field wiring, accommodation of the new hardware within the existing cabinet space, management of the entire I/O database, porting of the existing control strategies and all operator graphic displays into the new DCS with full factory test to avoid any on site retesting.
- If fieldbus or wireless technologies are to be considered, costs of implementation must be carefully benchmarked

1.3.4 Estimating Project Costs - OK

1.4 Benefits

- Needs updating
- Focus is on control performance improvements but there are many other areas of quantifiable benefits.
- NERC statistics need to be updated regarding annual outage hours attributable to boiler control systems (1.51 hrs) and burner management systems (1.00 hr)
- New benefits, for example, reduction of manpower through better automation.

1.5 Cost-benefit Analysis

- Needs updating
- Evaluation matrix should be revised to eliminate functional segregation.
- Include new financial arrangement in industry such as open markets and competition.

Vol. 1, Section 2, Project Approval and Planning

2.1 Final Conceptual Design – OK

2.2 Budget – OK

2.3 Integrated Project Schedule – OK

2.4 Project Team Organization, Management and Division of Responsibility

- When project involves integration of multiple systems, project team must include representatives of all impacted parties.

Vol. 1, Section 3, Project Implementation

3.1 Scope of Work – OK

3.1.1 File Search: documentation, drawings, and data

- On digital-to-digital upgrades, the control logic in the control system should be verified against the documented version of the logic.
- An interconnecting diagram of all systems connected to the DCS should be prepared if not already available.

3.1.2 Plant Activities – general – OK

3.1.3 Existing facilities and equipment status assessment – OK

3.2 Procurement specification and system design

- Section on bid evaluation could be added.

3.3 Engineering and design – OK

3.4 Installation design and drawings – OK

3.5 Installation – OK

3.6 Training

- Needs updating
- Training discussion should include use of simulators for operator and technician training
- Also, discuss computer based training.
- Knowledge capture.

3.7 Testing and start-up – OK

3.8 Verification of benefits – OK

Vol. 1, Section 4, Bibliography

- Needs updating
- The list of papers should be expanded greatly to include more recent publications and all the new topics such as digital-to-digital upgrades, plantwide control integration, fieldbus and smart field devices, security, advanced system, life cycle management.
- Below is a small sample of papers that should be added to the Bibliography from recent Joint ISA POWID/EPRI Control and Instrumentation Conferences.
  - Manufacturing and Control System Security – ISA SP99, History, Status, and How it can help you by Robert C. Webb, POWER Engineers, Inc., presented at the Thirteenth International Joint ISA POWID/EPRI Controls and Instrumentation Conference, Williamsburg, Virginia, June 15-19, 2003.
  - Application Challenges of a Fieldbus System by Regina Alves Ischaber Bratby, Washington Group International, presented at the Fourteenth International Joint ISA POWID/EPRI Controls and Instrumentation Conference, Colorado Springs, Colorado, June 6-11, 2004.
  - Layered Security in Plant Control Environments by Ken Miller, Ensuren Corporation, presented at the Fourteenth International Joint ISA POWID/EPRI Controls and Instrumentation Conference, Colorado Springs, Colorado, June 6-11, 2004.
  - The Future of Industrial Sensors – No Wires by Wallace Leuders, Accutech Div of Adaptive Instruments Corp., presented at the Fourteenth International Joint ISA POWID/EPRI Controls and Instrumentation Conference, Colorado Springs, Colorado, June 6-11, 2004.
  - A Control System Retrofit for an 80 mw Steam Turbine Generator Unit – a DCS Solution by N. S. Baptiste, The Power Generation Company of Trinidad and Tobago, presented at the Fifteenth International Joint ISA POWID/EPRI Controls and Instrumentation Conference, Nashville, Tennessee, June 5-10, 2005.
  - Control System Upgrade for Changing Electricity Market by Stephen Craig, ESB Ireland, presented at the Fifteenth International Joint ISA POWID/EPRI Controls and Instrumentation Conference, Nashville, Tennessee, June 5-10, 2005.
  - Operations Knowledge Management by Mark Perakis, EPRI, presented at the Fifteenth International Joint ISA POWID/EPRI Controls and Instrumentation Conference, Nashville, Tennessee, June 5-10, 2005.
  - Power Plant Automation Retrofits: Developing a Road Map from Lessons Learned…Experiencing Another 'Groundhog Day" by Sub Mohan and

Mike French, Power Generation Division, The Automation Group, presented at the Fifteenth International Joint ISA POWID/EPRI Controls and Instrumentation Conference, Nashville, Tennessee, June 5-10, 2005.

Vol. 1, Appendix A, Utility Survey Results and Summary (Task1)

- Needs complete revision
- Original survey is of little use today
- New survey should be considered as a part of the revised version of the report.

Vol. 1, Appendix B, Control System Performance Test Recommended Test Procedures

- Needs updating
- Update the methods of data collection during testing, analog recorders no longer used.

Vol. 1, Appendix C, Assessment of the Existing Facilities

- Needs updating
- Include existing communication systems between control systems and plant LAN.
- Include assessment of software revision status of existing digital control system.
- Include assessment of video based human machine interface systems.

Vol. 1, Appendix D, Assessment of the Existing Field Devices

- Need updating to discuss smart field devices and fieldbus technologies.

Vol. 1, Appendix E, Data Acquisition and Performance Monitoring System

- Needs general update
- Update computer technology to present standards.

Vol. 1, Appendix F, Sample Capital Cost Estimate

- Structure of this section is OK, but cost data is out of date and should be updated. It may be more difficult to get detailed cost data today than it was 13 years ago because of more concerns about competition in the industry.

Vol. 1, Appendix G, Project Economic Analysis

- The general discussion on economic analysis is OK but the specific discussion of the EPRI program called "Utility Cost Benefit Model" should be eliminated. Most power companies have their own economic evaluation software tools today.

Review of Volume 2

Vol. 2, Section 1, Technical Overview Control System Requirements

1.1 System Overview Requirements

- Generally OK but could use updating.
- Update HMI hardware reference "CRT" or equivalent electronic display devices.

1.2 Functional Capabilities

- Change "man-machine" to "human-machine"

1.2.1 Control Functions

- Programming device should reflect today's technology and not be restricted to "an IBM-compatible personal computer"

1.2.1.1 Continuous Modulatory Control

- Change Modulatory to Modulating.
- Update reference to SAMA and ISA functional diagram standards – page 1-3: the revised SP5.1 document and TR77.40.01 Functional Symbol Diagramming.

1.2.1.2 Sequential control

- Sequential control should be differentiated from binary control. Sequential control is specifically design for following a series of step in sequence. Binary control is general and/or gate logic but does not imply any specific sequence of steps.

1.2.1.3 Programming Languages

- Needs updating
- The role of general purpose programming languages has changed since the early 1990s. Few vendors offer BASIC or C languages in their control processor but they do provide an application programming interface (API) to allow custom programs to interface with the DCS control programs.

1.2.1.4 Documentation

- OK, but should expand on various forms of electronic documentation.

1.2.2 Man-Machine Interface Capabilities

- Functionality is OK
- Update to include new video display technology

1.2.2.1 Control Interfaces

- Incorporate new display technologies such as LCD monitors and large screen displays.
- Reference applicable industry standards such as ISA TR77.60.04 CRT Displays and RP77.60.05 Task Analysis.

1.2.2.2 Information Functions –

- The numbering of this section is not correct.

1.2.2.3 Plant Annunciation

- Recommendation for 48 window hard annunciator should be reconsidered.
- Reference applicable industry standards, such as, ISA TR77.60.02 Alarms.
- Reference to ANSI/IEEE Standard 676-1986 “Guide for Alarm Monitoring and Reporting Systems” should be updated.
- Guidance on proper alarm management with digital control systems should be provided. There is a tendency to provide far too many alarms on digital systems, but this results in "alarm overload" on the operators.
- Update references to CRT with video display system.

1.2.2.4 Trending

- This section is much too restrictive on trending capabilities.
- Artificial limits on trend history, etc., should be removed.

1.2.2.5 Indication

- This section is much too restrictive on indication capabilities.
- Remove all references to quantities of indicators.

1.2.2.6 Reporting

- The numbering of this section is not correct.

1.2.2.7 Logs - OK

1.2.2.8 Alarm Reports

- Remove references to quantities of alarms.

1.2.2.9 Operator Action Reports

- Remove references to quantities of events

1.2.2.10 Database Reports – OK

1.2.2.11 Graphics

- Functionality OK, but needs general updating to reflect modern display capabilities.

1.2.2.12 Historical Storage

- Needs updating to include off platform archiving systems
- Generally today, two archives are used. One within the DCS for short term storage to support operator trends, etc. The second one is off platform to support storage in perpetuity.

1.2.2.13 Analysis Functions

- This section needs a complete updating.
- Section on "operator guidance messages" needs reconsideration
- Expand on-line tuning to cover current EPRI work.
- Include section on Equipment Condition Assessment.

1.2.3 Methods of Communication

- This section is largely outdated and needs a complete revision.
- MAP is not used in power plants today.
- Include information on wireless protocols – 802.11 family, Blue tooth, Zigbee, Industrial Wireless.
- Include information on fieldbus standards – SP50 series, Foundation Fieldbus, Profibus, etc.

1.2.4 Need new section added on control system security

- Major new area of control system capabilities.
- Include information on ISA technical reports, TR99.00.01, "Security Technologies for Manufacturing and Control Systems," TR99.00.02, "Integrating Electronic Security into the Manufacturing and Control Systems Environment," TR99.00.03, "Audit and Metrics for Security Performance in the Manufacturing and Control Systems."

1.3 Bibliography

- The Bibliography in this section needs to be updated and merged with the Bibliography in Volume 1. The report should only have one Bibliography but it should be divided into functional topics.

Vol. 2, Section 2, Technical Overview Hardware Review

- This section provides vendor specific information about each vendors control systems. Consideration should be given to eliminating this section because the information changes so rapidly today that it will be out of date within a year. If the decision is made to keep this section, it will have to be completely redone and the list of vendors will need to be reviewed. One possibly valuable part of this information is the description of the evolution of the various vendors systems. This would provide users with a historical perspective on the systems and also clarify where their system fits in the overall history of the equipment.

Vol. 2, Section 3, Control System Retrofit Performance Enhancements

3.1 Available Capabilities to Achieve Improved Operation

3.1.1 Cyclic Operation

- Update this section with more discussion of operational flexibility and ancillary services.

3.1.2 Enhanced Process Monitoring

- Include discussion of equipment condition assessment using empirical models in this section.

3.1.3 Process Diagnostics

- This section could be merged with the 3.1.2 Enhanced Process Monitoring section

3.1.4 Advanced Algorithm Applications

- The functions described as "advanced" are really standard functions today. This section should be revised to include a discussion of truly advanced function such as multivariable control, optimization, etc.

3.1.5 On-line Performance Monitoring - OK

3.2 Required Plant Enhancements to Achieve Increased Operation – OK

- Discussion of EPRI report CS-2028 Identification of Root Causes of Plant Outages to Boiler Controls is obsolete and should be removed or updated if new information is available.

3.2.1 Plant Instrumentation - OK

3.2.1 Other Plant Equipment - OK

3.2.3 Control Rooms

- Manual/automatic stations are unlikely to be installed with any control upgrade today.

3.3 Options and Considerations for Range of Performance Enhancements - OK

3.3.1 Range of Performance Enhancements

- Values for process control improvements in Table 3-1 should be reviewed.

3.3.2 Additional Considerations to Achieve Maximum Benefits - OK

3.3.3 Options Available to Achieve the Maximum Benefits – OK

- This section primarily discusses a phased approach over several years to add enhanced capabilities to the base DCS. Other approaches such as advanced control techniques should also be described.
- Add options for fieldbus and wireless sensors to increase monitoring of plant.

Vol. 2, Appendix A, Control System Retrofit Cost Survey

- Results of vendor survey of costs for six example units. Cost data needs to be updated, if possible.

Vol. 2, Appendix B, Rosemount RMV9000 Distributed Control System

- This section was a last minute addition to the vendor information in section 2. The system is no longer used in the power industry, so this section can be eliminated.

Review of Volume 3

- Volume 3 contains several case studies written by users and designers. In 1993 these were all good studies with valuable information. Today this information is largely obsolete. But the idea of including case studies in the revised report is very worthwhile. Case studies should be included which discuss the new aspects of control system retrofits, such as, digital-to-digital retrofits, integration of control and information systems, use of smart field devices and fieldbus technologies, and many others. It is always useful to have access to others experiences before attempting something for the first time.

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