A INTRODUCTION TO MOP-21: *AUTOMATION OF WASTEWATER TREATMENT FACILITIES*

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ABSTRACT

After four years in preparation by a WEF task force (chaired by the author), the third edition of WEF Manual Of Practice #21 *Automation of Wastewater Treatment Facilities* was released at WEFTEC 2006. The manual attempts to answer the question, "What is a complete automation design?" It specifies the information required to make decisions needed to build an effective automation system and the types of documents – both text and drawings – that constitute a complete design. The manual also provides guidance on what data the documents should contain.

The new manual updates most of the topics from the 1993 second edition such as the chapters on instruments and control elements and completely revises chapters such as communications that have changed so much since 1993. It also introduces many new topics including chapters on "smart" process and instrumentation diagrams, human-machine interfaces, process control narratives, and specifications. Advanced applications such as energy management, artificial intelligence, and BNR control strategies are briefly introduced.

While it s not feasible to cover all of MOP-21 in a single session, this introduction will present the concepts and key material in the manual. It will demonstrate the use of the manual as a resource to solve common automation problems. The attendees will leave with a good understanding of the types of documents needed for an effective automation design and where to look for more information.

Control system designers, project managers, and utility managers will all benefit from learning more about what makes good instrumentation and control design.

KEYWORDS

Automation, Control, Design, Instrumentation, Strategies, Communications

WHAT IS A COMPLETE AUTOMATION DESIGN?

This is a relatively simple question that requires this all 546 pages of Manual of Practice No. 21 to fully answer in its entirety. The main purpose of the manual, therefore, is to define what information is required to make the decisions needed to build an effective

automation system. The manual introduces the types of documents, both text and drawings, that constitute a complete design and gives guidance to the content.

The design of automation systems requires a tremendous attention to detail – seemingly more so than other engineering disciplines. The design documents discussed in the manual reflect that attention to detail. Does this mean that every project needs every document discussed in the manual? The answer is a definite "No." However, almost every project with few exceptions requires that decisions on every detail be made before the automation system can be installed.

Whether those decisions are made by the design engineer, the general contractor, an electrical subcontractor, a systems integrator, a programmer, a CAD designer, the installing electrician, or the laborer digging trenches depends on the completeness and level of detail of the design documents. However, *someone* makes every decision about what to install, where to install it, where to land the wires, and how to program it. Whether that decision maker is a designer with an overall knowledge of the entire project or a contractor trying to meet the bid price depends on how much design the owner is willing to pay for and the technical competence of the designer. Hopefully the manual will impart the detailed knowledge needed to make these tradeoffs.

MOTIVATION FOR WRITING/UPDATING MOP-21

This is the third edition of Manual of Practice No. 21. The first edition was published in 1978 and the second fifteen years later in 1993. Although the automation field has matured considerably, it is still changing rapidly. Since the last edition was published:

- Researchers and practitioners have improved our understanding of physical, chemical, and biological treatment processes and the best strategies to control them;
- Manufacturers have begun creating field instruments specifically for the wastewater treatment industry (rather than adapting ones made for other industries;
- Field instruments typically have become less expensive, more accurate, easier to calibrate, and sometimes self-diagnosing because of digital electronics, better human interfaces, and other new technologies;
- Networking and wireless (radio) communications have become less expensive, provide more capabilities, and are widely available (e.g., fiber optic cabling has moved from an expensive exotic to an everyday commodity);
- Programmable logic controllers (PLCs) and distributed control systems (DCSs) continue are smaller, perform better, have more capabilities, and less expensive;
- "Standardized" PLC programming tools based on the 1993 International Electrotechnical Commission (IEC) 1131-3 standards are now being used extensively;

- Personal computers (PCs) operate even faster, have more capacity, are less expensive, and – along with their related software - dominate the automation market;

- Shrink-wrapped, PC-based supervisory control and data acquisition (SCADA) software is now readily available and relatively inexpensive (but requires extensive configuration);

- SCADA systems now features typically include the monitoring, control, trending, and data features that most users need, and many also include historical data archiving, reporting, fuzzy control (a formal methodology for representing, manipulating, and implementing a human's heuristic knowledge about how to control a system), artificial neural networks, and model predictive control (a class of controllers that use a model of the process to computer a sequence of manipulated variable adjustments to optimize the future behavior of the process);

- The Internet now plays an important role in dispersing information and is evolving into a platform for wide-area control systems;

- Physical and cyber security have become important issues on every automation project;

Twenty-eight years ago, the authors of the first edition noted that because automation is a rapidly changing field, the manual would need frequent updates. This is still true today.

WHAT THE MANUAL DOES AND DOES NOT INCLUDE

When the Water Environment Federation's Automation of Wastewater Treatment Facilities Task Force first defined the scope of the update, they estimated that the manual would be about 500 pages - considerably longer than the 1978 edition(108 pages) and 1993 edition (332 pages) - to accommodate new developments in the field.

After considerable discussion on what to keep, add, or leave out the task force decided to update much of the material in the previous editions, except for obsolete technologies such as pneumatic transmission systems. The task force also incorporated much of the content of the 1984 edition of Manual of Practice No. OM-6 *Process Instrumentation & Control Systems.* However, the task force decided not to duplicate WEF's 1997 Special Publication *Automated Process Control Strategies*, which is currently the latest on specific process controls strategies for wastewater treatment systems. The task force also decided not to debate the relative merits of traditional design-bid-build and design-build contracts or address construction management issues. Nor did the task force address collection system controls in this edition, because that topic deserves its own publication.

HOW TO USE THIS MANUAL OF PRACTICE

Each chapter is written to stand alone, so the manual does not need to be read from cover to cover. Readers looking for specific information should simply turn to the appropriate

chapter. For more information on a particular topic, see the references or general bibliography included I each chapter.

Chapter 1 is an introduction to MOP-21.

Chapter 2 discusses the business case for automation and stresses that control systems should support the utility's vision of effectiveness and efficiency. Investments in automation should and can result in measurable reductions of labor, chemicals, and electrical power while improving performance and reliability. The ten "Keys to Success" are introduced.

Chapter 3 introduces the elements of a complete automation design project. Each type of document is briefly discussed and standards and references are delineated.

Chapter 4 talks about what is often one of the first design documents developed for a project – the process and instrumentation diagram (P&IDs). The elements of a P&ID are developed and the interactions with other design documents are discussed. Recent developments in "smart" P&IDs are also introduced.

Chapter 5 introduces the general characteristics of instrumentation including properties and measures of accuracy. Design considerations such as temperature, moisture, corrosion, and grounding are discussed.

Chapter 6 is a discussion of the major types of instrumentation used at wastewater treatment plants. This chapter has been greatly revised to account for recent improvements in instrumentation and the newer instruments specifically developed for solids treatment.

Chapter 7 discusses final control elements used to affect control at treatment plants. Topics include valve and valve actuators, pumps and pump characteristics, blowers and blower characteristics, motors, variable frequency drives, and other control elements.

Chapter 8 develops the characteristics of local control panels. Special consideration is given to environmental requirements, thermal management, and panel instrumentations

Chapter 9 is dedicated to signal transmission and data communications. This chapter has been largely revised from previous editions to include material on networking, fiber optics, and new wireless communication technologies.

Chapter 10 is a tutorial on the basics of process control going from feedback controllers to advanced model-based control.

Chapter 11 discusses the functionality of a process control system in general and the human-machine interface (HMI) in particular.

Chapter 12 is dedicated to the design of control system hardware including programmable logic controllers (PLCs) and distributed control systems (DCSs).

Chapter 13 develops the process control narrative – a text-based method of describing a process control strategy. Several example control narratives for common processes are developed.

Chapter 14 is a brief introduction to some of the advanced applications and tools that are being applied at treatment plants including energy management, decision support, modeling and simulation, artificial intelligence, and BNR plant control strategies.

Chapter 15 is an introduction into writing specifications. The Construction Specifications Institute (CSI) format is documented and an example specification developed. A list of potential specifications for a "typical" automation project is developed.

Chapter 16 is an introduction into instrumentation maintenance. The difference between instrumentation maintenance and maintenance of rotating equipment is discussed.

Chapter 17 is a brief introduction into troubleshooting instrumentation systems.

And finally, chapter 18 is a discussion of instrumentation documentation and training.

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