APPLYING S88

BATCH CONTROL FROM A USER'S PERSPECTIVE

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Foreword

To grossly paraphrase Nietzsche, serving on standards committees either kills you or makes you stronger. After six years of bimonthly international meetings involving hundreds of batch professionals, costing the sponsoring companies millions of dollars, accommodating thousands of end-user comments, boosting frequent flyer accounts to record highs, and leveling whole forests to produce the twelve intermediate drafts required to reach consensus, the ISA S88 Committee produced ANSI/ISA-S88.01-1995: Batch Control Systems, Part 1: Models and Terminology. The standard promised to unify the world of flexible process manufacturing with a common framework, finally allowing engineering, operations, vendors, and customers to use a common language to describe, design, and deliver agile plants.

While momentous, clear, and enlightening to the hard-core committee members, the standard proved in practice to be more of a *reference* than a *guide* to automation engineers. There were a few who vowed to write application guides to supplement the standard, but most approaches cover a superset of the S88.01 material, treating the many aspects of batch automation necessary to successfully architect and manage large teams. However, there is a need for strong examples and case studies that breathe life into the theory. That is where this book comes in.

While attending the Rockwell Consumer Products Roundtable a few years ago, I ran into Jim Parshall for the first time. He was holding court on the finer points of making ice cream, waving his arms, and genuinely having a good time explaining the process to those around him. I was instantly struck by his outgoing and enthusiastic attitude about applying computers to flexible manufacturing. He moved throughout the crowd, challenging whomever he encountered to a discussion on segmenting a plant, architecting a PLC, or laying out a graphic display. His combination of technical expertise and dynamic, engaging style appealed to the attendees and helped them understand his message. This book is written in the same style, telling the story of Ben & Jerry's first foray into the world of agile manufacturing. Jim and Larry breathe life into the technical details of S88.01, and the result is both entertaining and informative. With the standard as a companion, this book serves as a cookbook for success, guiding the S88 "newbie" through the perilous terrain of justifying, specifying, designing, and deploying a truly flexible process manufacturing system.

June 1999
Michael Saucier
Chairman and Founder of Sequencia Corporation

Introduction

You probably remember reading a chapter from an engineering or math textbook and thinking to yourself, "I'm sure the author knows what he's talking about, but I'm just not getting it." So you read the chapter again. And you still didn't get it. You chugged or repeatedly sipped your favorite caffeinated beverage. Ah, but that didn't work either. So you highlighted the chapter with three or four different colors to outline what you thought were the important notes or equations. Your impending headache made you swallow a couple of aspirin with another jolt of caffeine. Maybe you just gave up and went to bed.

Well, as embarrassing as this may sound, reading the S88.01 standard reminded us a little bit of our college days. We know the SP88 members certainly have the qualifications to write such a spec and worked long and hard producing it. In fact, during the past several years we have had the pleasure of meeting several of them. Unfortunately, the nature of any standard or regulation prevents its authors from providing lengthy examples and details for interpreting it. Since standards serve countless companies in many different industries, they must be written to cover the broadest ground or they would never be published. (We defy you to tell us that *immediately* after reading any section of the FDA's "Good Manufacturing Practices" you understood *exactly* what the FDA meant.) But hey, let's not make any excuses: S88 just wasn't sinking in.

As we reviewed S88 and spoke with industry experts, including vendors, committee members, and other users, we took notes to strengthen our understanding of the standard. Our installation of RSBatch to control Ben & Jerry's mix-making operation in 1998 was a very strategic project for the company because RSBatch was a key component to improve manufacturing efficiencies and information handling. Integrating RSBatch with Ben & Jerry's existing process control system required a lot of planning, so we continued to take notes before and during the installation.

From our notes during that project we wrote this book. (We didn't dare write it from memory.) It's about what we think S88 means and how we used *our* interpretation to redesign our existing batching system. Our hope is that you'll only need one highlighter to capture the important points. We didn't have the good fortune to serve on SP88, so we don't consider our solutions to be definitive. In other words, we may not have implemented S88 exactly like others, but what we did worked well for us. In fact, we're proud to say that the system, including the human-machine interface (HMI), was designed, developed, and retrofitted into existing hardware and software in fewer than five hundred person-hours and that the very first batch of mix created with the new system was successfully used in finished product. (For any reader without an automation background, *HMI* is a manufacturing term that refers to a graphical user interface or "GUI." Some

people may use the term *operator interface*. Folks who want to give away their age use the terms *operator interface terminal* or *OIT*.)

By now, you may think that we're using the terms *S88*, *S88.01*, and *S88* somewhat interchangeably. No, these aren't typos. (Hey, let's give our editor some credit, after all.) Each of these has a very distinct meaning: S88 is the overall standard name, S88.01 is part one of the standard (it has two parts), and SP88 is the name of the committee that authored the standard. These terms are explained in more detail early in Chapter 1.

How We Chose S88 and RSBatch

The Ben & Jerry's plant in St. Albans, Vermont, started running its mix making system in the summer of 1995. All batching functions were controlled via relay ladder logic (RLL) in Allen-Bradley PLC-5s and PanelViews. (Personal computers were not part of the process control system in 1995.) Once we eliminated the initial bugs the system was quite stable, as long as ingredients and processing steps stayed the same. That first batch control system quickly helped turn the St. Albans plant into the company's volume leader.

However, as a growing company committed to remaining competitive in the marketplace, Ben & Jerry's is constantly introducing new products and reformulating existing products. While many of these products used existing base mixes, some required new mixes. Well, you guessed it: many of these new mixes required new ingredients and new processing steps.

After introducing several new mixes, we concluded that our existing PLC-only mix-making control logic wasn't flexible enough to handle all of our new products. In addition, our method for collecting data was fairly primitive. Operators were tired of writing all recipe ingredients out by hand, along with target quantities, actual quantities, and the raw ingredient tanks used in each batch. (It was rumored that Ben & Jerry's was the largest purchaser of stainless steel clipboards in northern New England.) St. Albans had significantly reduced mix-making manufacturing variances since its start-up, but we knew we could do better. However, without more automatic and accurate data collection, even trying to perform a simple analysis of our process became a chore.

So, we set out to find a better way to run our mix-making system. We noticed something peculiar when reading batch control books: they didn't discuss using ladder logic to run and manage recipes. At first, we just figured the books were written from a perspective that favored distributed control systems (DCS), in which scripting-type languages are used for batch control.

However, while reading *Batch Control*, edited by A. E. Nisenfeld and H. Leegwater (ISA, 1996), we noticed the S88 standard being mentioned prominently throughout the text. We also couldn't help noticing the popularity of S88 in various trade magazines, so we decided to do a little research on S88.01 and

ordered the standard from ISA. While we couldn't grasp all the concepts initially, we both thought following a standard for batch control was at least worth some investigation.

Meanwhile, while making a presentation at Allen-Bradley's Consumer Products Roundtable in March 1996, Jim met Michael Saucier, the founder of Sequencia (then known as PID). Sequencia created and is marketing OpenBatch, a PC-based batch control software package that follows the S88 standard. About that time, Rockwell Software announced that it had licensed OpenBatch and would be marketing it under the name "RSBatch." (Other companies, including Honeywell, Siemens, and AspenTech, have also since licensed OpenBatch and integrated it into their batch solutions.)

There are several "S88-aware" solutions in industry today, including products from Sequencia, Rockwell, Wonderware, Intellution, Siemens, Honeywell, Fisher-Rosemount, Moore Products, ABB, Yokogawa, and GSE. After reviewing the alternatives, we concluded that OpenBatch was the best solution for us.

Ben & Jerry's formed an alliance with Rockwell Automation in 1993 in which Rockwell would be Ben & Jerry's exclusive provider of critical control system components, such as PLCs, operator interfaces, discrete control panel components, frequency drives, and motor starters. Ben & Jerry's relationship with Rockwell Automation was very strong, and so Rockwell Software's decision to license OpenBatch strengthened our favorable opinion of the product. OpenBatch can work with all kinds of different control systems, and Allen-Bradley PLCs can work with many S88 batch packages. Because of our commitment to our alliance with Rockwell Automation and our satisfaction with that relationship, we decided to purchase RSBatch. (It's also easier to justify projects that include products and services from alliance partners.) However, to appeal to a wider audience (in hopes of higher royalty income), we've written this book to educate users who are working with any S88-aware solution. Furthermore, we'll also use the term *OpenBatch* instead of *RSBatch*.

Before we go any further, we do need to make one thing clear: we're not saying batches can't be controlled exclusively using ladder logic or that they shouldn't be (after all, the St. Albans plant used ladder logic for three years and has left the original PLC code in place as a backup). We're just saying it ended up not being the best way for us.

Besides retrofitting an existing control system with new software (versus installing an entirely new system), we did something else that was not common: we designed and implemented the system ourselves. Plenty of very qualified system integrators and consulting companies, including Rockwell and Sequencia, could have installed it for us. But we had the resources available and the personal interest to do it ourselves. What we're going to tell you—and what the examples we're going to use will show you—is not what we read, saw, or managed. They are what we *did*.

What You Should Read Depends on Who You Are

We believe this book can help educate just about anyone in an organization that uses batch control. In the following table we have listed suggested chapters to read based on your role at your company. We believe these apply if you work for a manufacturing company or if you're working at a vendor, an original equipment manufacturer (OEM), or a consulting firm.

If you are:	Think about reading:
An automation or controls engineer	The whole kit and caboodle
A project engineer or project manager	Almost the whole kit and caboodle: skip Chapter 12
An automation or controls technician	Chapters 1 through 8 and 11 through 14
An operator	Chapters 1 through 8 and 13 and 14
An information technology (IT) systems analyst in manufacturing	Chapters 1 through 10 and 13 and 14
An engineering or IT supervisor	Chapters 1 through 7 and 13 and 14
A mid-level manager and above (including a company executive)	The first two parts of Chapter 1 and all of Chapter 14

How We Chose to Organize This Book

So this is the story of how we implemented an S88-aware batch control system. In the first chapter, we begin discussing batch manufacturing so that we'll all start on the same page, literally and figuratively. Still in Chapter 1, we introduce S88 as a concept and a philosophy, throw entity-relationship (E-R) diagrams and sequential function charts at you, and describe our mix making process. Chapters 2 and 3 discuss critical project activities, like gathering customer requirements, selling the concept (getting money), managing the project, and scrounging dinners from vendors. Starting with Chapter 4, we dig into the meat (or tofu for you vegetarians out there) of S88.01. For those of you who have read the standard, please be patient with us. We do not follow its thought progression exactly. We'll introduce S88 models in Chapter 4, talk about recipes in Chapters 5 and 6, discuss equipment control in Chapters 7 and 8, and review important aspects of information handling in Chapter 9. So that you get your money's worth, we're also going to discuss specifying a batch control system in Chapter 10, designing phase logic in Chapter 11, and writing phase logic in Chapter 12. Chapter 13 is about starting your new system, including dealing with validation activities. We wrap things up in Chapter 14.

We didn't implement every detail of S88 in St. Albans because we didn't need to. But for this book we have also worked with industry experts to fill in the gaps. If you're not an OpenBatch (or PSBatch or Total Plant Batch) user, don't fear: you

will learn and profit hugely from reading this book. We didn't write it to be a replacement user manual for OpenBatch, RSBatch, or Total Plant Batch. For those of you using batch solutions from Intellution or Fisher-Rosemount, this book will be more helpful to you than you may think. The core functionality of their products is very similar to OpenBatch.

You just can't please everybody, so we know there will probably be at least three groups of people who aren't going to like this book. The first group will be S88 committee members, who'll be disappointed because we're not going to interpret the standard exactly the way they intended. The second group includes engineers who implemented S88 differently than we did but who at least *think* they implemented their solution "the right way." The third group includes people much smarter than us, who'll find our interpretation of S88 offensively simple.

On the other hand, committee members who authored S88, engineers who have already implemented S88, and those who believe they truly understand the standard probably don't need this book. We hope you do—that you really have no idea what S88 is all about or at least you would like a guide to using it. After reading this, maybe you'll think we're both S88 geniuses and hire us as consultants for obscene fees.

On with the show.

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