Introduction

The production of SBQ Steel products is continuously becoming more complex in nature in order to meet increasingly demanding applications and customer requirements. As a result, the definition, management, and communication of the product specifications necessary for production have become increasingly difficult. In particular, areas of concern are industry and customer specific requirements definition, revision control, complex scheduling, routing and material tracking, verification of test results for conformance to requirements, and conformance documentation such as Certified Material Test Reports. Development of a model to be able to accommodate this complex requirement is the subject of the paper.

Quad Infotech has developed software for defining, managing and communicating product specifications to meet complex SBQ production requirements. This includes formal review and approval functionality to aid in maintaining compliance with quality standards such as ISO9000 and QS9000. In addition, the product specifications can be used as an integral part of the quality testing functionality in [QMOS] to verify conformance to requirements for each order to ensure production meets customer specifications.

This software can be used in conjunction with the existing [QMOS] modules for management and operations personnel to Plan, Schedule, Optimize, Report and Analyze production on a real time basis.

The need for an integrated intelligent specification system

As a business grows their SBQ market, so increases the complexity of the product specifications and more onus is placed on the scheduler and Quality Assurance department to communicate the appropriate customer requirements for each production order.

The creation of the schedule many times is a manual process in which the scheduler creates the production orders by combining sales orders of like products and requirements. The scheduler uses experience and in-depth knowledge of the customer base to identify orders with potentially special requirements that may require dedicated production orders. Reviewing the customer’s requirements in common forms such as specification books and customer files or legacy systems is often necessary to determine if any special requirements are required that must be cited on the scheduled production order. This manual process must be carried out each time the new schedule was to be published making it a time consuming and arduous task not to mention error prone.

In addition, with new mill improvements common in the industry, the increased production, coupled with more SBQ orders for custom sizes, grades and lengths means increased workload for the scheduler.

In operations, the supervisors and operators have to refer to the reference on the schedule and review the entire specification in the legacy system to decipher the specific requirements for the order. In addition, often not all information is contained in a single source and multiple systems and books may have to be consulted in order to ensure all requirements are known. Further, when operators are required to perform tasks such as custom tag printing, they must again refer to another source and manually type in the special requirements for the order. This manual process must be carried out for each special order making it a labor intensive and error prone practice.

In addition, the Quality Assurance department’s task of managing the various sources of information for all to use is also a time consuming, arduous and error prone process. Those facilities that must also focus
on maintaining ISO and/or QS quality standards certification have an added level of complexity in the management of product requirements.

The main focus of developing the product specification structure are:

- 1. Consolidate all product requirements into one system.
- 2. Improve management of specifications to meet ISO and QS quality standards
- 3. Reduce scheduling time and work load by automatically determining like sales orders (products with like specifications)
- 4. Reduce/eliminate manual errors in citing special order requirements
- 5. Improve communication of special order requirements to production personnel
- 6. Reduce/eliminate manual operator input of special requirements for tasks such as custom Tag Printing

**Design**

The product specification design was based on already proven [QMOS] concepts and technologies. A Product Specifications data model was designed to integrate with the existing Product Definition [QMOS] model. The main functions of the Product Specifications system were then designed and programmed to meet standard quality system management requirements and common specification management and communication practices in the industry.

The data model was structured around a hierarchy of Standard Product Specifications, Customer Specifications and Order Specifications in which Customer Specifications supersede the Standard Specifications and Order Specifications that supersede the Customer Specifications. This hierarchy and the integration with the rest of [QMOS] are illustrated in Figure 1.

![Figure 1 Integration of Product Specifications](image)

Specification Definition is an integral part of Sales, Production Scheduling and Production and as a result has been designed to integrate with each of those areas in the steel manufacturing process. Specification Definition is designed as a separate functionality from the rest of [QMOS] that can be used as a specification management system as well as integrated with other [QMOS] modules.
Specification Definition

Specification Definition is based on the principal that all requirements can be categorized and quantified in the same manner. In this design, requirements have been quantified by three categories: Numeric Limits, Boolean and Text. Examples of each are shown below and illustrated in Figure 2:

Both Standard Product Specifications and Customer Specifications can be stored together. In order to simplify the definition of specifications, the customer is left out. The customer is only specified when tying the specs to the Product Code. Details are described in a later section.

Since different customers may have different limits for the same requirements, the concept of the Specification Version was introduced. In this way, the same specification can have different variations that may be used by any Product Code and any Customer. For example, A36 Version 1 may have standard ASTM chemistry limits but A36 Version 2 may have 0.25 Cu max. Now that Version 2 exists, any Customer and any Product Code can use that specification. This also eliminates the need for creating additional Product Codes just to identify different limits for the same specification. An example of different versions may be seen for grade specifications for 1005R and 1006R in Figure 3 in which the O2 spec is 20 max for Version 2.
Each specification is also defined with a Test in order to facilitate the definition of the details of the specifications by filtering the list of Elements to those that have been defined for the Test. For example, a Chemistry specification will not display UTS, Yield, Elongation as elements for selection and a Mechanical specification will not display C, Mn, P etc as elements for selection. The Test Definition screen may be seen in Figure 4.

Figure 4 Test Definition

A very powerful feature of the design is the concept of using a Work Center as a part of the specification definition. With Work Center the user can specify for which operators the specification is pertinent. As the example in Figure 3 illustrates, the Grade specification 1005ML is pertinent to the LMF Work Center. [QMOS] will use this information to determine which screens and ultimately who will see this specification by use of their Login ID, which is defined with a Work Center. This means that the operators do not have to sift through all specifications for the order to find those that are pertinent for them.

In addition, for a single Version, multiple Work Centers may be defined each with their own set of limits. This eliminates the need to create new specifications and still set different limits for different stages of the steel making process. This is very useful for establishing EAF and LMF chemistry limits where the EAF Work Center must meet specific chemistry before production can be moved on to the LMF Work Center. Similarly, the Rolling Mill Work Center may have its own limits for dimension specifications while QA Work Center has the absolute limits.

In order to reduce manual errors in checking specifications and ensure nonconforming material is always placed on Hold, a specification can be specified with automatic Hold for all nonconforming material when a test fails to meet specifications. Figure 3 displays the Hold checkbox that identifies this specification as requiring any nonconforming material to automatically be placed on Hold. This Hold designation is designed to be at the Work Center level in order to accommodate those specifications that may have process only requirements in one Work Center such as the EAF chemistry, and absolute limits in another Work Center such as LMF chemistry.

**Process Specifications**

In addition to product specifications this design will also provide the ability to define some process specifications that operators need during the manufacturing process. Such specifications include Tap Temperature, Superheat, Casting Speed, Reheat Temperature, Finishing Speed, # of samples, Bundle Weight, Tag Type etc.

It is proposed that most Process Specifications can be stored in the same structure as Product Specifications using the Numeric Limits, Boolean, and Text categories. Similarly if test results are recorded for those specifications, verification of conformance to requirements may be done. For example, Casting Speed may be monitored and compared to the limits specified and if they are exceeded an alarm may be generated with the potentially nonconforming material automatically placed on Hold.
Product Code

The basis behind the integration of the Product Specifications with the rest of [QMOS] is the Product Code. The Product Code is a code used to identify the material being ordered by the customer akin to a Part Number or Catalogue Number and as a result, each sales order is placed for a specific Product Code. This Product Code is then carried throughout the rest of the production process as the identifier of the item that must be produced. As is the case with many steel making businesses, Product Codes are defined by key characteristics such as Shape, Size, Grade, Length. As a result, unique Product Codes are created for different combinations of those key characteristics. Since some businesses have more or less key characteristics to define their Product Codes, [QMOS] was designed to require a unique Product Code but allow any variation of key characteristics. An example of Product Codes is illustrated in Figure 5.

Since the Product Code is the cornerstone of product definition, it will also be used as the cornerstone for Product Specifications. Product Specifications are connected to a Product Code so that when an order is placed for a Product Code the specifications can be resolved directly through the Product Code.

Product Specifications

Product Specifications are connected to Product Codes in two ways: Product Specs and Customer Specs. Product Specs are the standard or normal requirements regardless of customer. This may include industry standards such as ASTM, SAE, DIN etc or standard manufacturer’s instructions such as the company’s internal practices. In general, every Product Code should have a Product Spec as the standard requirements for making that product. An example of Product Code Specs may be seen in Figure 6.
Customer Specs are the non-standard specifications that pertain to a customer’s requirements for a product. Therefore, in addition to any Product Specs, a Product Code may have Customer Specs connected to it as well. This Customer Specification structure eliminates the need for creating additional Product Codes just to identify customer requirements.

There are two cases for definition of Customer Specs. One case is when the customer does not want the standard Product Specs but instead wants some variation thereof. For example, instead of the standard Carbon range for a grade, the customer requires a tighter range. In this case, the customer spec is considered an override to the standard. The second case is when the customer requires additional specs that the standard does not. For instance, the customer may require that a non-structural grade meet specific mechanical limits. In this case, the spec is considered additional to the Product Specs. An example of the Customer Specs may be seen in Figure 7.

![Figure 7 Customer Specs](image-url)

There is another case in which the customer specifies requirements that are not part of their normal requirements and are intended as one-time only specifications for an individual order. These specs are considered Order Specs and don’t fall into either the Product Specs or Customer Specs category. Therefore, Order Specs are not connected to a Product Code but rather to the sales order itself. Those requirements may be specified in a Note field on the sales order and will be automatically transferred to the production work orders. These requirements are considered overrides to both standard and the normal customer specs.

**Revision Control**

The principal of revision control is based on changes made to Product Code Specifications rather than a single specification. For instance a customer changes their chemistry requirements from 0.30 Cu max to 0.25 Cu max. A new specification would be created as a version of the previous specification and tied to the same Product Code. An Effective Date is used to specify when the new change is to go into effect. As of that date, the old specification becomes obsolete and the new specification becomes active. This is also a powerful feature since the user is not required to time the updates in the system to the specifications with actual orders or production.

Specifications for a Product Code are never deleted in order to maintain complete revision history. The user will see all changes made as separate specifications for the Product Code.

**Specification Resolution**
When resolving the full requirements for an order, all three types of specifications will be taken into consideration and the hierarchy used to determine the actual order requirements each time. An example of the Specifications screen may be seen in Figure 8.

![Figure 8 Specifications](image)

**Review and Approval**

In order to manage the changes and maintain compliance with quality standards such as ISO and QS, a formal Review and Approval functionality has been designed to work with specifications. The changes made are communicated through email to the various persons responsible for review and approval and are not active until all necessary persons have approved the change. An example of the Review and Approval screen is shown in Figure 9.

![Figure 9 Review and Approval](image)

**Scheduling**

Product Specifications are used to aid in scheduling by eliminating the manual workload involved in working up a schedule from sales orders. This automated feature is a complex function that resolves the order requirements for each order and combines like orders to be produced at the same time. The orders must have the exact same specifications for the work center being scheduled in order to be combined. One of the main reasons for exact same requirements is to provide the operators the correct information for each order automatically.
At the push of a button, [QMOS] will combine sales orders booked for a specific rolling to create work orders for production and sequence the work orders according to user defined production sequencing rules for that work center. The scheduler may re-sequence as needed and modify the quantity.

**Tag Printing**

As an order is being packaged, the [QMOS] Tag Printing will automatically extract the necessary tag information defined in Product Specifications and display it on the screen for the operator to review. If necessary the operator may modify. This eliminates the need for the operator to keep in mind which orders require special tagging and which do not. [QMOS] manages the information and provides the operator with all the necessary information for each order automatically.

Similarly, custom paperwork such as Certified Material Testing Reports and Shipping documents can be automatically generated based on the defined specifications.

**Summary**

The Product Specifications model is the basis for automating, streamlining and reducing errors in many business functions in the steel manufacturing process. This model provides great flexibility in allowing the user to customize their specifications to meet their specific business needs while enforcing common specification management and communication practices.

Some of the advantages that the new Product Specifications model can provide plant wide are as follows:

- 1. Eliminate the need to create extra Product Codes just to handle customer specific requirements.
- 2. Customizable Product Specifications and Tests can be defined by the user at any time to fit unique customer and business requirements.
- 3. Reduce customer claims by eliminating errors and reduce time with formal specification management and maintain ISO/QS standards.
- 4. Improve Sales response time regarding product specification inquiries.
- 5. Reduce customer claims by eliminating release of non-conforming products through automated specification verification.
- 6. Reduce customer claims by eliminating custom tags and paperwork errors.
- 7. Consolidate all specifications in one system and display the order requirements plant wide instantly.
- 8. Reduce scheduling time by automatically generating Work Orders based on customer requirements.

**References:**

1. [QMOS] Design Documents
2. [QMOS] User Manual

The list of [QMOS] modules are as following:

- [RSP]: Roll Shop Planner
- [PSP]: Mill Scheduling & Product Set Up
- [GSP]: Guide Shop Planner
- [BCI]: Bearing and Chock and Stand Building
- [SBI]: Saw/Shear Blade Inventory
- [PRR]: Production Control & Reporting
- [STP]: Shift Planner and Production Analysis
- [BTC]: Bundle Tag Control
- [PSC]: Production Scheduling and Control
- [BYM]: Billet Yard Management
- [MPC]: Melt Shop Production Scheduling & Control

[QMOS] Modules

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