

Integration of Component Design Data for Automotive Turbocharger with Vehicle Fault Model Using JA6268 Methodology

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ABSTRACT

Suppliers and integrators are working with SAE's HM-1 standards team to develop a mechanism to allow "Health Ready Components" to be integrated into larger systems to enable broader IVHM functionality (reference SAE JA6268). This paper will discuss how the design data provided by the supplier of a component/subsystem can be integrated into a vehicle reference model with emphasis on how each aspect of the model is transmitted to minimize ambiguity. The intent is to enhance support for the analytics, diagnostics and prognostics for the embedded component. In addition, we describe functionality being delegated to other system components and that provided by the supplier via syndicated web services.

As a specific example, the paper will describe the JA6268 data submittal for a typical automotive turbocharger and other engine air system components to clarify the data modeling and integration processes. It will describe how data submittals are structured to support IVHM analytics, diagnostics and prognostics. We conclude with a discussion of how the design data aspects of these components would be certified as "SAE JA6268 Health Ready" and how the supplier can use this certification to increase the competitiveness of the component/system in the market place.

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INTRODUCTION

An overview of the JA6268 Methodology is shown below.

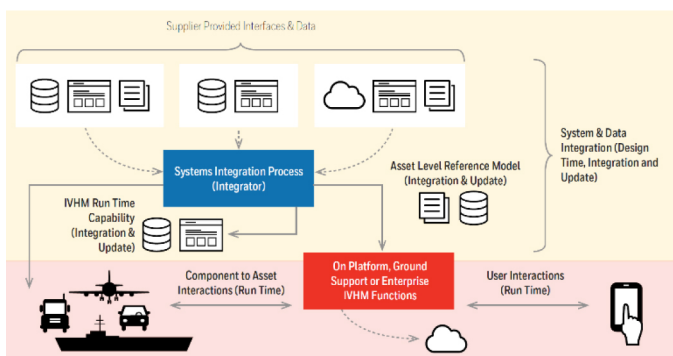


Figure 1. Overview of JA6268 Health Ready Component Methodology

This paper will focus on the portion shaded in yellow at the top half of the figure.

OVERVIEW OF CONTENT OF IVHM INTEGRATED REFERENCE MODEL

The data provided by the design time data submittals is used to build an IVHM Integrated Reference Model (IRM) which consists of a Fault Model, a Processing Model and an Advisory Model. Each of these models are described below.

The Fault Model specifies the characteristics of the functional failure modes of the component and its inputs and their effects on the outputs and symptoms of the component. The primary relationships include:

- Symptoms Affected by Abnormal Values of Inputs
- Outputs Affected by Abnormal Values of Inputs
- Symptoms Affected by Internal Failure Modes
- Outputs Affected by Internal Failure Modes

The model also contains a set of secondary relationships between items. These relationships are secondary because they model interactions that flow in the opposite direction of material and energy in the system:

- Inputs Affected by Abnormal Values of Other Inputs
- Inputs Affected by Failure Modes
- Inputs Affected by Abnormal Value of Output
- Inputs Affected by Failure Mode
- Outputs Affected by Abnormal Value of Other Output

An example of the model for an example pump that encodes these relationships is shown below.

OIL PUMP

Inputs	Affected Inputs	Drive Torque	Supply Fluid	Affected Symptoms	Excess Heat	Excess Noise	Excess Vibration	Affected Outputs	High Pressure Fluid
Drive Torque	X								X
Supply Fluid		X					X		X
Failure Modes									
Pump Restriction	X			X	X	X			X
Air Injection	X				X	X			X
Blocked Output	X					X			X
Outputs									
High Pressure Fluid	X					X			X

Figure 2. Example Fault Model Content for Pump (Simplified)

In this figure, the primary and secondary relationships needed by the model are encoded in the cells relating a row to a column. An “X” in a cell indicates that the item associated with the row is related to the item associated with the column.

It is important to note that the Fault Model also contains specification of Assemblies, Interfaces, Connections, Functions and Operating Modes. Most of these entities are not needed when modeling a single component but become critical when modeling a system or platform.

The Processing Model specifies the dynamic models between I/O variables and specifications for data collection, data trending and algorithms to generate additional diagnostic and prognostic indicators and algorithms to generate prognostic estimates of time-to-fail (aka remaining useful life). Examples of the information included in the Processing Model are shown below.

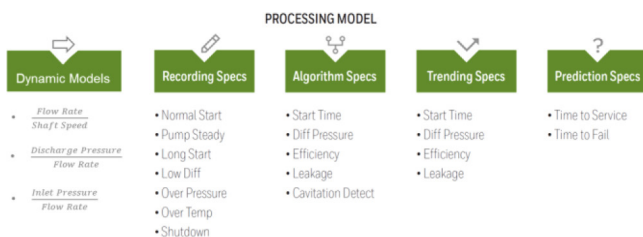


Figure 3. Content of Processing Model for Example Pump

The Advisory Model contains the information needed to interact with the user and to command system functions as required to isolate and correct any detected faults. Content of the Advisory model includes

links to repair procedures, manual test procedures, initiated test procedures and links to Option Codes that allow a single model to encode effectivity of entities based on versions and variants of the component, system or platform. Examples of content of the Advisory Model for the pump example are shown below.

ADVISORY MODEL

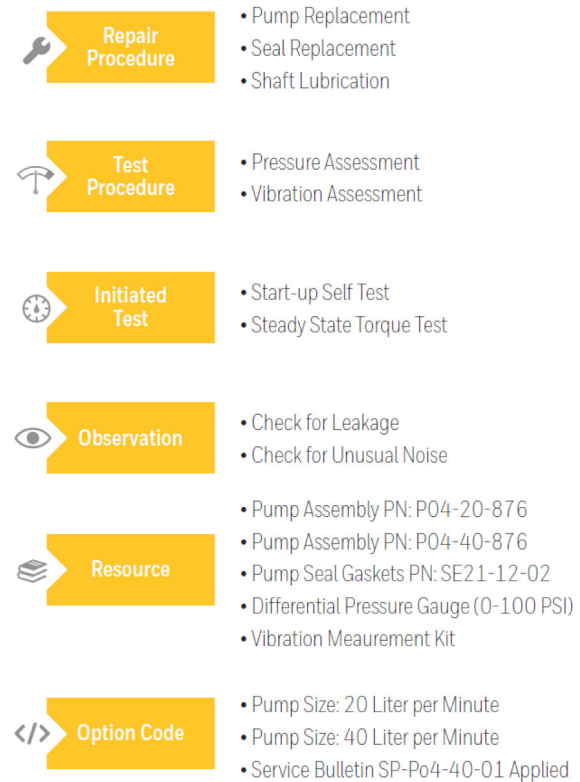


Figure 4. Example Content of Advisory Model for Pump

All three of these sub-models are combined to produce the Integrated Reference Model.

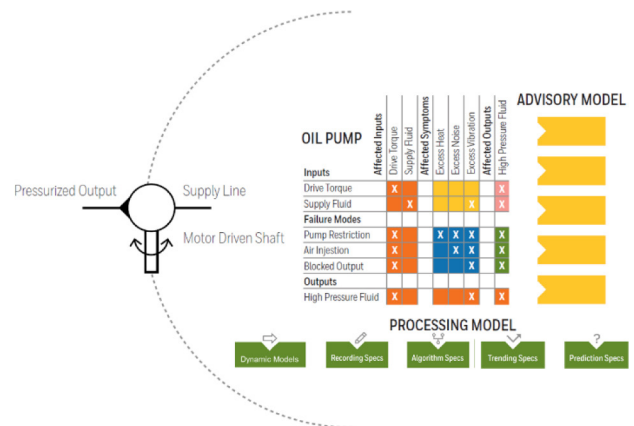


Figure 5. Integrated Reference Model for Typical Component

It can be useful to understand the mapping of the elements of the IRM to the typical functionality of an IVHM system using ISO 13374 as a nominal example. The following figure illustrates that mapping.

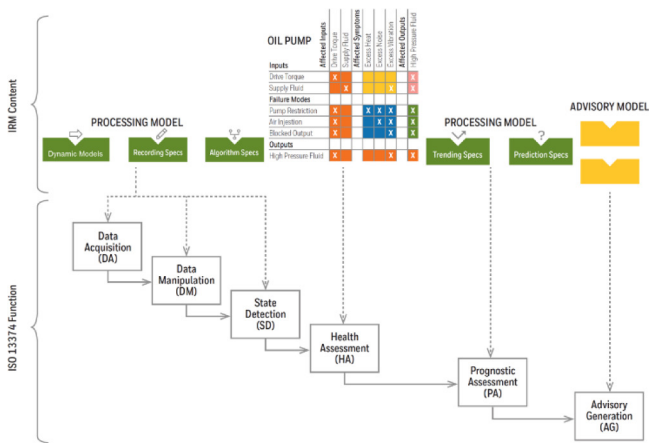


Figure 6. Mapping of IRM Content to ISO 13374 Functionality

It is important to note that many IVHM implementations include changes to sequencing and interactions between ISO 13374 functions that are not shown in Figure 5 but the mapping of IRM content to the functions remains the same.

An overview of the entities and relationships included in the Integrated Reference Model that is used for the design data submittal is shown below.

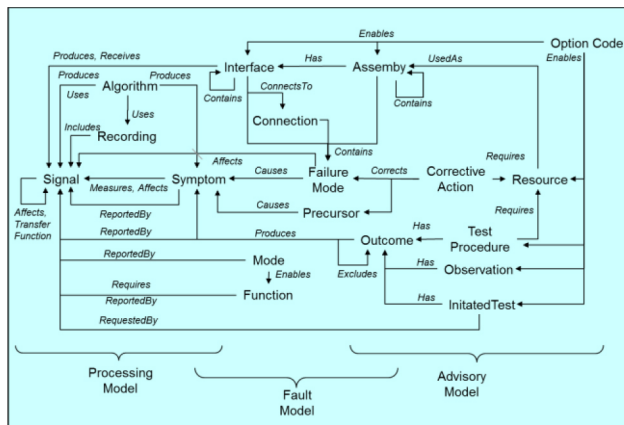


Figure 7. Overview of Content of JA6268 Data Model

Reference Models for components can be combined with other data to produce Integrated Reference Models for systems and platforms. This data is used to configure the data recording, trending, analysis, diagnostic and prognostic functions. These functions can be deployed for execution on the platform or for use on maintainer terminals or other enterprise computing infrastructure.

Again, a complete Reference Model for a component will not require all of these entities and relationships but the most of them will be required for the model for a subsystem, system or platform.

DIAGNOSTIC CHARACTERISTICS OF AUTOMOTIVE TURBOCHARGER AND AIR INTAKE SYSTEM

A turbocharger uses an engine's exhaust gas to drive a turbine wheel at speeds up to 280,000 rpm.

The turbine wheel is connected by a shaft to a compressor wheel and the two wheels turn together to draw in and compress large amounts of ambient air. This air is very dense and very hot, so it is passed through a charge-air cooler, where it cools and gains even higher density before entering the engine. The presence of this compressed air makes the fuel burn more efficiently, thereby delivering greater power while consuming less energy.

An overview of the functionality of an automotive turbocharger is shown below.

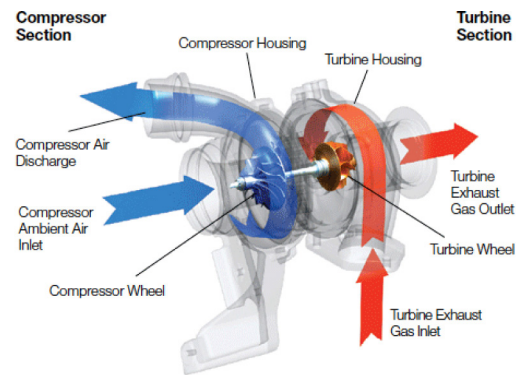


Figure 8. Turbocharger Fundamentals

The turbocharger is a key element of the Engine Air Intake System as shown below. It is important to recognize the failure modes in the turbocharger will have manifestations that overlap with manifestations of failure modes in other air system components. A key of objective of JA6268 is to capture the mappings of failure modes to manifestations with sufficient fidelity to allow for automation of the fault isolation process.

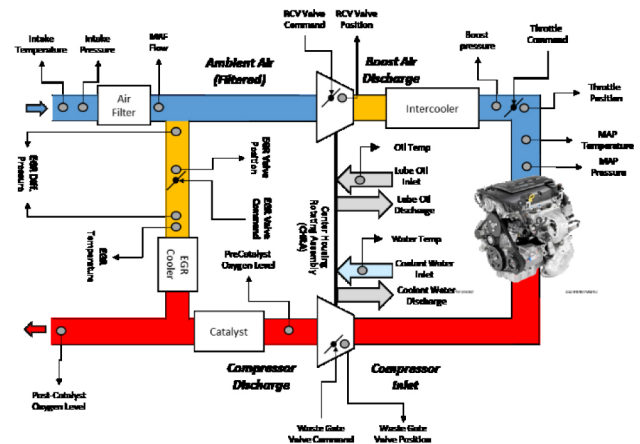


Figure 9. Engine Air Intake System Overview