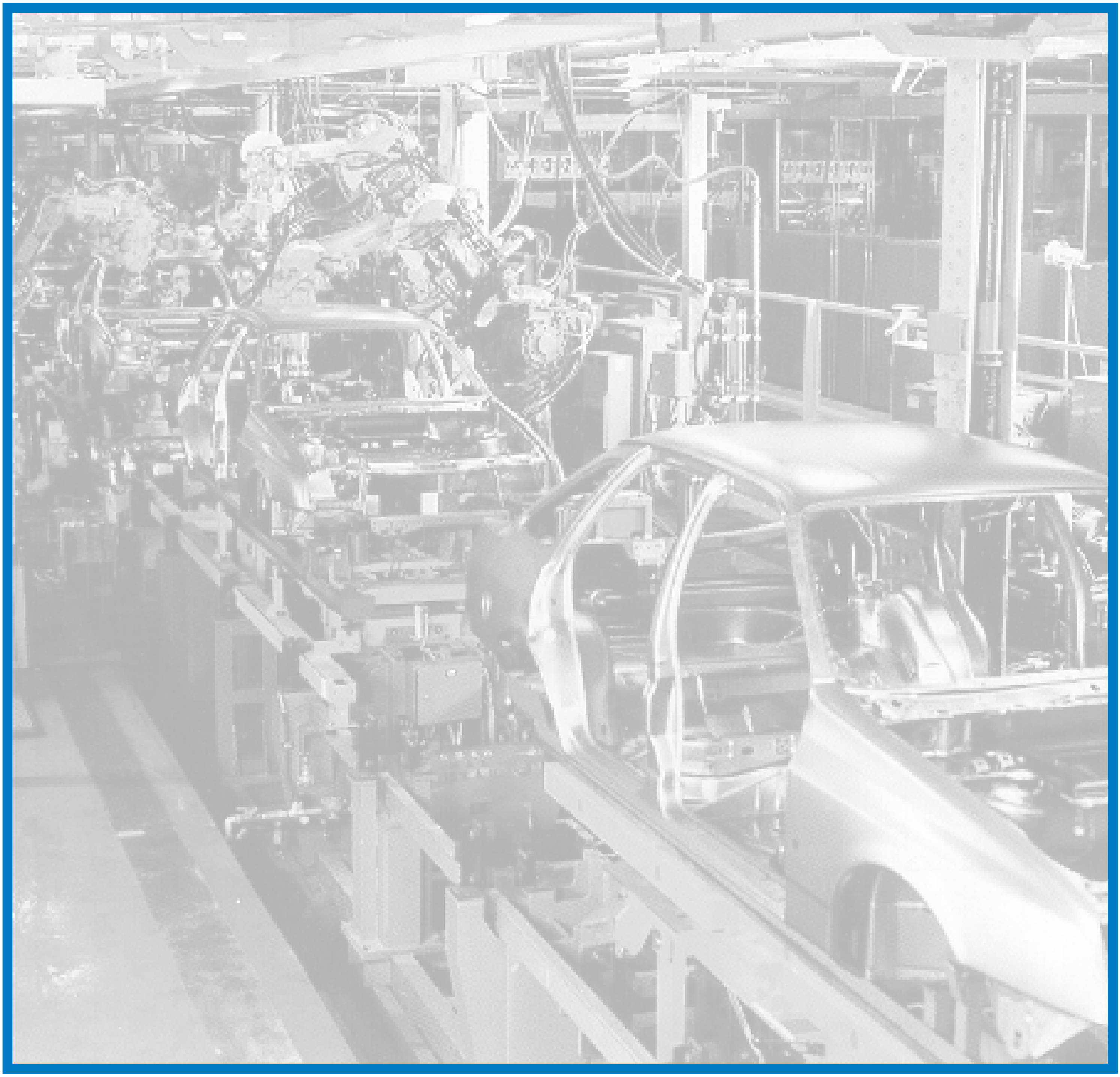

Event-Based Functional Build: An Integrated Approach to Body Development

Executive Report

A summary of recommendations for moving toward a "functional build" paradigm.

Auto/Steel Partnership

Event-Based Functional Build: An Integrated Approach to Body Development

Executive Report

Auto/Steel Partnership Program
Body Systems Analysis Project Team
2000 Town Center - Suite 320
Southfield, MI 48075-1123
2000

Auto/Steel Partnership

AK Steel Corporation
Bethlehem Steel Corporation
DaimlerChrysler Corporation
Dofasco Inc.
Ford Motor Company
General Motors Corporation
Ispat Inland Inc.
LTV Steel Company
National Steel Corporation
Rouge Steel Company
Stelco Inc.
U. S. Steel Group, a Unit of USX Corporation
WCI Steel, Inc.
Weirton Steel Corporation

Body Systems Analysis Project Team

J. Aube, General Motors Corporation
H. Bell, General Motors Corporation
C. Butche, General Motors Corporation
G. Crisp, DaimlerChrysler Corporation
T. Diewald, Auto/Steel Partnership
K. Goff, Jr., Ford Motor Company
T. Gonzales, National Steel Corporation
R. Haan, General Motors Corporation
S. Johnson, DaimlerChrysler Corporation
F. Keith, Ford Motor Company
T. Mancewicz, General Motors Corporation
J. Naysmith, Ronart Industries
J. Noel, Auto/Steel Partnership
P. Peterson, USX
R. Pierson, General Motors Corporation
R. Rekolt, DaimlerChrysler Corporation
M. Rumel, Auto/Steel Partnership
M. Schmidt, Atlas Tool and Die

This publication is intended for use by Auto/Steel Partnership members only. For more information or additional copies of this publication, please contact the Auto/Steel Partnership, 2000 Town Center, Suite 320, Southfield, MI 48075-1123 or phone: 248-945-7777, fax: 248-356-8511, web site: www.a-sp.org

Abstract

The Auto/Steel Partnership (A/SP) is an innovative international association that includes DaimlerChrysler, Ford, General Motors and eleven North American sheet steel producers. The Partnership was formed in 1987 to leverage the resources of the automotive and steel industries to pursue research projects leading to excellence in the application of sheet steels in the design and manufacture of vehicles. The Partnership has established project teams that examine issues related to steel properties including strength, dent resistance, surface texture and coating weights, as well as manufacturing methods including stamping, welding and design improvements.

The report is one of a series published by the Auto/Steel Partnership Body Systems Analysis Project Team with the support of the Manufacturing Systems staff at The University of Michigan's Office for the Study of Automotive Transportation. This report has two versions: an executive report and a full report. This executive report provides a basic overview of functional build and its benefits.

The report summarizes recommendations for moving toward a new "functional build" paradigm for the automotive body by tightly integrating the many individual activities ranging from body design and engineering through process and tooling engineering. Revised stamping die tryout and buyoff processes receive special emphasis, as does the launch of stamping and assembly tools.

North American automotive manufacturers traditionally have utilized a sequential process validation approach for the automotive body. This begins by validating individual components, then small sub-assemblies, ultimately leading up to the finished body. This approach assumes that the quality of each higher level assembly is predicated on the quality of incoming, lower-level components. Validation at each step usually is measured by quality indices such as C_p and C_{pk}. This sequential approach has proven non-competitive for car bodies, often resulting in missed development schedules and unnecessarily high costs for process rework.

A functional build approach to process development would focus on the customer. This approach shifts the development focus from optimizing individual components to the entire car body, and integrates product, process and manufacturing. Required changes are identified based upon lowest-cost solutions which might involve modifications to a product design, a stamping die or an assembly process. This research helps to identify the regions which should reduce the amount of subjective decision making. By using an integrated validation approach such as functional build, manufacturers will accelerate the product development cycle while saving costs in process development.

Introduction

Functional build provides a new paradigm for process validation of the automotive body and its components. Using functional build rather than validating components solely to their part print specifications, manufacturers evaluate components relative to their mating parts and subsequent assembly processes. They work to produce part dimensions to original specifications, but they treat these specifications as targets rather than absolute requirements. Thus, if manufacturers experience difficulty meeting a particular component requirement, they may resolve the problem in a downstream assembly process or change another related, mating component more expediently. By analyzing components in their subsequent assemblies, manufacturers also may find that certain original requirements are not critical to the final product build. Here, a modification to the design drawing is less expensive than physically changing completed stamping dies.

Functional build represents a fundamental shift from the traditional, sequential validation approach. Under sequential validation, manufacturers first validate their stamping processes as being capable of meeting all design requirements. After each component is approved, companies sequentially validate the sub-assembly processes, and then the complete body-in-white. This sequential approach subscribes to the basic belief that final product quality will be maximized if each individual component meets all of its performance requirements.

Although sequential process validation appears logical, it has often proven non-competitive for the automotive body build. Vehicle manufacturers typically set fixed dates for the start of a new production model. Thus, any delays for process validation of individual components reduces the allotted time for final body validation. In certain extreme cases, the difficulties encountered trying to achieve process capability requirements for individual body components have even delayed final process validation until after the start of production. With sequential validation, manufacturers focus more attention on meeting requirements for individual components than on the principal concern of the customer, the completed product.

When functional build is used, manufacturers realize substantial cost and time savings over a traditional process and product development cycle. These savings result from eliminating unnecessary process rework during the validation phase. The principal reason for these savings is that under functional build, rework decisions focus on meeting final vehicle objectives and not necessarily on conformance to all original component specifications.

Recurring Stamping Dimensional Conformance Challenges

The adoption of functional build practices has arisen primarily in response to three recurring body development challenges:

- An inability to simultaneously produce all stamping component mean dimensions at their nominal specifications,
- Limitations in measuring non-rigid stamped parts and
- Weak correlation between component dimensions and their resultant assemblies.

This report explores these challenges using dimensional conformance data from a benchmark study at seven automotive manufacturers: DaimlerChrysler, Ford, General Motors, Nissan, NUMMI (Toyota), Opel and Renault. Each manufacturer conducted an experiment involving a body side assembly and its major stamped components. They obtained 36 samples for each component across six different stamping runs (six samples per run) and then assembled these panels into 36 body side assemblies. These case studies provide dimensional data on stamping and assembly capability in addition to stamping-to-assembly correlation.

Automotive manufacturers typically collect measurement data for individual body components at several locations. Ideally, manufacturers would like to produce each stamped component such that the mean value at each measurement location is at its nominal specification. Figure 1 below provides a histogram of mean values for 143 dimensions across five body side components. This histogram suggests the die construction and tryout processes result in stamped parts whose mean dimensions are normally distributed. In other words, rarely do manufacturers simultaneously produce all component mean dimensions at nominal. Depending on tolerances, manufacturers typically have between 20% and 40% of their stamping dimensions failing the generic North American automotive industry quality standard of a $C_{pk} > 1.33$.

The difficulty with producing all mean dimensions to nominal is not unique for any one manufacturer. Table 1 below provides a comparison of mean deviations and C_{pk} conformance for the seven manufacturers in this study. The data suggest that lack of mean and C_{pk} conformance is an industry-wide problem. Other empirical studies also confirm the difficulties in producing sheet metal components with dimensions meeting their original nominal specifications, particularly for larger, non-rigid components such as a body side panel.

Company	% Dimensions [Mean] > .5	% Dimensions [Mean] >tol	% Dimensions C_{pk} <1.33
A	37%	36%	64%
B	47%	37%	79%
C	34%	6%	36%
D	37%	19%	53%
E	22%	12%	51%
F	23%	34%	62%
G	31%	29%	61%

Table 1. Mean and C_{pk} Conformance by Manufacturer

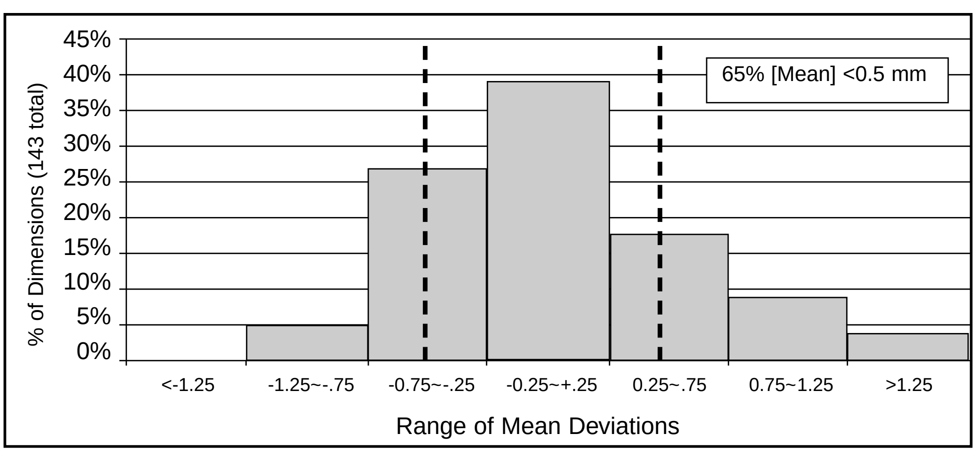

Figure 1. Histogram of Mean Deviations

Mean dimensional deviations often are attributed to difficulties in predicting metal flow during forming operations. Another less recognized problem is the difficulty associated with measuring large, complex-shaped components. Automotive manufacturers measure body components in absolute, three-dimensional space. For rigid structures, they typically use a 3-2-1 fixture layout, which requires six degrees of freedom to locate a part in space prior to measurement. For large, non-rigid parts, however, body manufacturers must use additional clamps or locators to stabilize the part for measurement. One concern with these additional locators is that they actively influence the location of the surfaces being measured. In other words, the positioning of the locators, not the geometry of the stamping dies, is the source of some mean deviations. Table 2 below considers the effect of locating strategies on dimensional conformance of body side outer panels. Companies E, F, and G use significantly more cross car clamps and have greater mean conformance. This over-constraining strategy also allows them to assign tighter tolerances.

The above limitations are further influenced by the lack of adjustment factors to shift stamping dimensional measurements. Many processes have built-in mechanisms, or setup parameters, which allow manufacturers to shift critical part dimensions to a nominal value. In the case of sheet metal stampings, this is not always true. Changing the dimensions of a component requires a physical change or rework of the dies, often an expensive and time-consuming process. Such rework may involve several iterations, especially for large parts with complex shapes. Even after several rework iterations, manufacturers cannot always correct every mean dimensional deviation. A functional build approach allows some individual component dimensions to remain out of their initial design tolerance, provided the assembly meets its specifications and functions properly.

For manufacturers using sequential validation, mean deviations severely impact the product development process. Under sequential validation, companies typically use C_p and C_{pk} indices to approve parts for the next validation phase. Both indices are related to the ability of a process to produce outputs within their specification limits. For example, C_p is the total tolerance / 6 x standard deviation. The C_{pk} index differs from C_p because it includes the deviation of the mean from its nominal in assessing process capability.

Empirical studies of stamping tryout suggest that even though manufacturers may achieve C_p requirements, they often fail to meet C_{pk} requirements due to significant mean deviations from nominal. In other words, their processes have sufficiently low variation but are away from nominal.

Company	Body Side Type	# Cross Car clamps in fixture	Average [Mean]	Average $6\sigma_{part-part}$	Average $6\sigma_{total}$
A	Integrated Quarter	11	1.10	1.14	1.41
B	Integrated Quarter	14	0.73	1.09	1.93
C	Two-piece	7	0.51	0.99	1.88
D	Two-piece	8	0.88	0.99	1.21
E	Two-piece	22	0.36	0.48	0.52
F	Two-piece	16	0.31	0.32	0.49
G	Integrated Quarter	17	0.37	0.40	0.77

Table 2. Mean and Variation Conformance

Unfortunately, shifting all mean values on a component to their original nominal specifications has proven not to be feasible. Of the 366 body side component dimensions studied across the seven manufacturers, more than 60% of the dimensions did not meet C_{pk} requirements. Interestingly, many of these manufacturers are producing acceptable finished bodies even with this lack of C_{pk} compliance.

Automotive manufacturers using C_{pk} criteria for sequential validation ultimately modify original design tolerances to approve stamped components for production. These modifications are generally made using either tolerance expansion (e.g., from +/- 0.5 to +/- 0.7) or a lateral tolerance adjustment (e.g., +/- 0.5 to 0+1 if mean = 0.5). These common modifications of original tolerances to pass C_{pk} requirements suggest a basic futility in the use of this index for approving sheet metal components.

Another recurring automotive body manufacturing problem is a lack of correlation between stamping components and their welded assemblies. For rigid structures such as engines, manufacturers assume that dimensions will stack-up in the mating of two components. The assembly mean and variance are thus based on a linear addition of the two component means and variance. The additive theorem of variance suggests that the assembly variance will be greater than the component variances. Based upon this additive assumption, manufacturers try to produce individual component mean dimensions at their nominal specification with minimal variance. These manufacturers further assume that they may predict their assembly outputs based on the measurements of the input components (i.e., input component dimensions are correlated with their assembly outputs).

These assumptions are not always valid for non-rigid stamping components. These components may continue to deform during subsequent weld processes. Some components will resemble more closely the geometry of the fixtures used to orient them at time of assembly than their initial measurements. Non-rigid component dimensions also may conform to more rigid dimensions during assembly. The net effect is that non-rigid component measurements often poorly predict final assembly measurements.

Table 3 below provides a summary of the dimensional relationships between stamped body side components and their respective assemblies from the case studies. These data suggest two key observations. First, coordinated measurements, or measurements taken in the same physical location before and after assembly, shift unpredictably during the weld assembly process. Nearly half of the dimensions exhibited mean shifts of four and five sigma from stamping-to-assembly (typical sigma values = 0.1 ~ 0.2 mm). Second, virtually none of the dimensions exhibited a strong correlation between manufacturing processes.

		% of Dimensions	
Company	Number Coordinated Dimension	Correlation (*R*) > .6	[Stamp Mean- Asm Mean] Difference>
A	32	3%	66%
B	104	8%	65%
C	32	6%	66%
D	31	0%	48%
E	32	0%	34%
F	8	0%	50%
G	77	1%	61%

Table 3. Correlation of Part Dimensions Before and After Assembly

Several explanations exist for this lack of correlation between individual components and their respective assemblies. Among them are:

- Deformation of metal during the weld process,
- Changes in the part locating schemes,
- Conformance of non-rigid component dimensions to other rigid areas of the assembly, and
- Measurement system errors.

This lack of correlation presents serious ramifications for the traditional sequential validation approach. Here, manufacturers rework dies during tryout at both the tooling source and the production facility to meet C_{pk} criteria for component dimensions. Manufacturers using sequential process validation estimate that this rework accounts for 20 to 30% of the die costs. The above correlation analysis suggests that this rework may have minimal impact on the final body dimensional accuracy. During one study of a vehicle launch, the manufacturer found that 70% of all root causes of final body dimensional variation were due to assembly fixture failures. Thus, if launch dates are fixed, delaying assembly tryout to rework individual components may not allow sufficient time to resolve the primary causes of final body dimensional problems.

The effects of die rework are not limited to additional die construction and tryout costs. Several manufacturers maintain that numerous rework iterations for a set of component dies also impact the reliability of the tooling. Constant grinding and welding of dies increases the likelihood of subsequent tooling failure. North American manufacturers maintain that because of this concern, they must design dies that are more robust or costly than do some Japanese manufacturers.

The difficulties associated with producing components with mean dimensions at nominal, coupled with the lack of correlation between non-rigid components and their subsequent assemblies, have led some manufacturers to abandon the traditional sequential validation approach which uses C_{pk} as the primary decision criteria. As with many processes, the use of statistical indices such as C_{pk} without integrating product/process knowledge results in sub-optimal decision-making. To integrate manufacturing experience and knowledge into the validation process, these manufacturers are replacing sequential validation with a functional build approach.

The Functional Build Process

A functional build approach leads manufacturers to evaluate components in relation to mating parts. Components need not strictly comply with their original design specifications. If a part assembles into an acceptable car body, it is not modified regardless of whether it meets C_{pk} requirements.

Figure 2 below considers the mating of the center pillar reinforcement to the body side panel. This center pillar reinforcement is a structural component and thus will have greater influence on the final assembly. If the body side panel is 1 mm outboard from the centerline of the car, but the center pillar is at nominal, the overall assembly will likely shift toward nominal. This shift occurs because the mating surfaces are parallel. Thus, the less rigid body side panel will conform to the more rigid inner structure. Under the traditional approach, a manufacturer would likely rework the body side panel because the outboard stamping condition would cause this part to fail its C_{pk} requirements. In contrast, a functional build manufacturer would assemble these two components and make rework decisions based on the resultant assembly and not necessarily on C_{pk} compliance of individual stamping dimensions. The resultant assembly might still deviate from nominal, but the manufacturer may find it easier to adjust an assembly process locator than physically alter a stamping die.

The functional build evaluation process typically involves the construction of screw-bodies. Most manufacturers construct screw-bodies off-line using fixtures or bucks. Rather than build special fixtures for each sub-assembly, some manufacturers add extra locators to sub-assembly check fixtures to allow them to “slow build” the stamped components.

One of the most common misconceptions of functional build is that it evaluates assembly robustness to stamping variation. Functional build manufacturers only build a few screw-bodies for each sub-assembly. Thus, the principal effect of constructing screw-bodies is an evaluation of mean deviations and not variation. This requires manufacturers to first establish short-term process stability prior to functional build evaluations.

Functional build evaluations typically occur in two phases. In the first phase, evaluations are made using parts off regular production dies but at the construction or tooling source. This evaluation process provides a mechanism to support decisions regarding the acceptance and shipment of dies (“die buy-off”) to the production facility. In this process, manufacturers consider both the actual dimensional measurements of the components and their relationship to mating components. The primary objective of this phase is to correct those problems known to affect subsequent assembly operations, while delaying rework decisions for those non-conforming dimensions with unknown

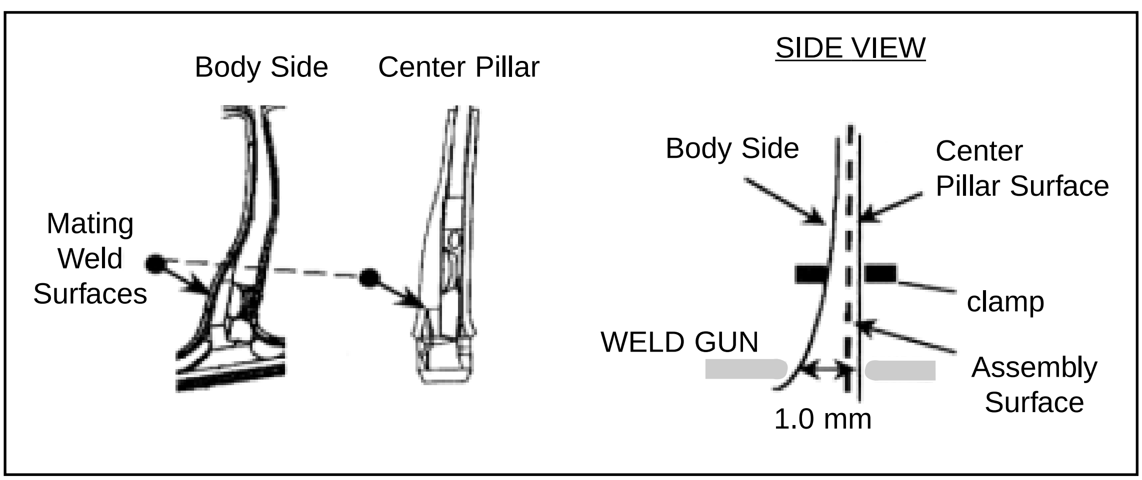

Figure 2. Parallel Assembly of a Non-rigid Mating Surface to a Rigid Reinforcement

impacts. The second functional build phase occurs after the dies are shipped to the production facility. The primary objective for this evaluation is to produce a dimensionally acceptable finished body. A manufacturer may even choose to rework certain in-tolerance dimensions if the changes will improve the overall manufacturability or appearance of the final body.

The screw-body sub-assemblies are built into full screw-bodies, usually one or two per car model. Manufacturers usually assemble both the sub-assemblies and the full screw-body prototypes with screws or rivets instead of the normal welding operations. They use screws or rivets to minimize the component distortion caused by welding. Thus, screw-body assemblies help to determine whether individual components can produce an acceptable sub-assembly or final assembly. Manufacturers assume that if the screw-bodies are acceptable, they may eventually set weld tooling to match them. Thus, the screw-body process also provides a technique for setting-up and tuning-in welders.

Event-Based Functional Build

A fundamental issue in developing a functional build strategy is how manufacturers address timing vs. dimensional conformance conflicts. These conflicts occur when a component does not meet its dimensional requirements at the time of a validation event such as the first functional build screw-body. Manufacturers must decide whether to proceed with an event using components with known problems or delay the build until the parts meet all requirements. Reasonable arguments may be made for either decision. By delaying the build, the effectiveness of the build evaluation increases because components more closely reflect their production conditions. Conversely, meeting all timing deadlines is critical to managing the overall development process because of the inter-dependencies with other concurrent and subsequent activities. Delaying the evaluation of a body side assembly to wait for the body side stamped component could subsequently delay the evaluation of the center pillar. Certain extreme cases may arise where a particular component does not even remotely resemble the intended part and a special recovery plan may be needed. However, if the majority of dimensions are within specification, manufacturers typically will benefit more from performing the evaluation at this point than delaying the overall process. Empirical evidence further suggests that meeting timing deadlines is critical to realizing the potential savings in time associated with a functional build approach. Thus, under the event-based functional build approach, timing is sacred.

Under this philosophy, manufacturers should view dimensional criteria as goals rather than absolute requirements. In other words, manufacturers should make every effort to meet all submittal goals, but ultimately should submit components based on timing. Given this timing priority, manufacturers may question the effectiveness of even having dimensional goals. The argument in support of goals is that meeting them lowers the likelihood of rework following a functional build evaluation.

One implementation issue with an event-based approach is allocating resources to make die modifications between build evaluations. Under event-based functional build, manufacturers may delay certain die rework or engineering changes at the die source in order to meet timing deadlines. In this scenario, manufacturers should not expect to ship dies immediately following the functional build evaluation. One benefit of a modification period following functional build is that manufacturers may batch change screw-body rework requests with late engineering revisions.

Functional Build Submittal Criteria

Most manufacturers using the traditional validation approach rely on C_{pk} as the main criteria for determining dimensional acceptance. One alternative to using C_{pk} for part approval is to separate mean and variation conformance (note: C_{pk} combines them). The principle behind this approach is that for non-rigid sheet metal components, controlling variation about the mean is more critical than the relative location of the mean to a design nominal.

To evaluate variation, this study supports the use of C_p or CR (Capability Ratio = $1/C_p$). These indices effectively measure short-term process capability and identify whether the expected range of stamping variation is less than the specified tolerance. This assumes that the design tolerance represents the robustness of the assembly process to the variation of incoming stamped parts. Requiring that the variation is stable also improves the estimate of the mean deviation. Large shifts in stamping means between or within any phase of development hinder the estimate of the process mean and subsequently the effectiveness of screw-body evaluations.

From a total systems perspective, a dimensionally acceptable stamped part might be defined as one that is capable of producing an acceptable assembly. It might also be agreed that low stamping standard deviations are universally desired over larger ones. Disagreements over panel acceptability, however, occur in quantifying allowable mean deviations.

Numerous cases exist where assembly processes may compensate for mean deviations. In some instances, these mean deviations may even exceed the original specifications. Although failure to produce mean dimensions at nominal may not always affect the build, it is important to recognize the need for eliminating excessively large mean deviations. Moreover, parts with a large percentage of dimensions exceeding their tolerance requirements typically are rejected in functional build evaluations.

Figure 3 below suggests that if manufacturers can produce 80% of the mean dimensions within specification and a maximum mean deviation less than 0.5 mm out-of-tolerance, a part will have a high likelihood of acceptance.

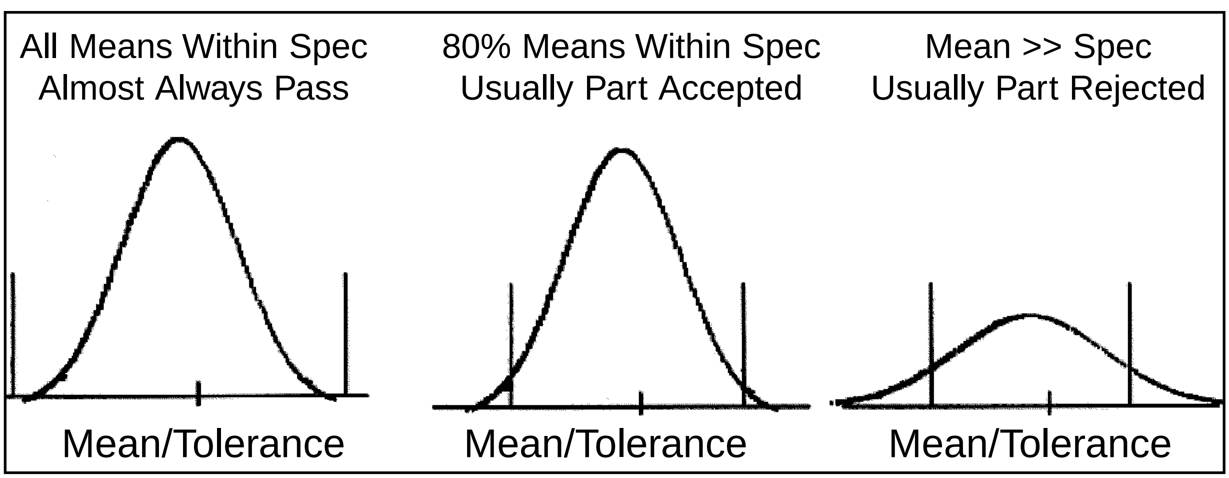

Figure 3. Mean Distributin and Part Acceptance

Sub-assembly Build Issues

Under the functional build process, manufacturers evaluate components based on the ability to produce an acceptable assembly rather than solely on dimensional conformance to specifications. However, what is an acceptable build? Does it mean that all sub-assembly dimensions are at nominal? Or that all sub-assembly dimensions are within specification? Or that the components have the potential to produce all sub-assembly dimensions within specification?

In defining an acceptable assembly, it is necessary to re-examine the reasons for implementing a functional build approach. First, consider the issue of part rigidity. It may be argued that traditional mean stack-up models are ineffective if the mating parts lack rigidity. Although mating components may be non-rigid, resultant assemblies typically are not. This suggests that manufacturers are less likely to compensate for out-of-specification sub-assembly dimensions and therefore should strive to produce sub-assemblies closer to nominal. Similar to stamping processes, assemblers also have difficulties simultaneously producing every assembly dimension at nominal. In addition, manufacturers may improve the dimensional conformance of a sub-assembly by making adjustments to weld tools. Following this logic the decision to rework a stamped part dimension off nominal relates to its potential to produce a dimensionally correct sub-assembly and not solely based on the results of a screw-body build constructed prior to assembly tooling adjustments.

Defining an acceptable assembly based on potential to produce sub-assembly dimensions to nominal involves risk. Some dimensional decisions that are delayed until complete evaluation of weld tools eventually may require die rework. Manufacturers must be cautious of delaying too many decisions based on potential to compensate in assembly because of resource limitations to make changes. This leads to a similar argument for defining acceptable assemblies as that used for stamped components.

Mean dimensions across an assembly are often normally distributed. This normality affects the ability to meet Cpk criteria for all sub-assembly dimensions. Again, separating mean and variation conformance is proposed. In the area of variation conformance, the use of process capability indices such as C_p or CR is recommended to demonstrate the inherent ability to produce assembly dimensions within the tolerance width. On the issue of mean conformance, tighter requirements than those found in stamping are proposed because of the lower likelihood to compensate for out-of-specification dimensions due to higher rigidity.

Empirically, it may be shown that sub-assembly mean deviations within 50% of their assigned tolerances rarely prevent manufacturers from meeting final vehicle requirements. Table 4 below examines sub-assembly conformance for two benchmark vehicles with excellent body gap quality. While neither manufacturer meets C_{pk} requirements for all sub-assembly dimensions, both produce the majority of mean sub-assembly dimensions within 50% of the tolerance limits with relatively few sub-assembly mean dimensions outside their specifications (~ 6%). This is based on assembly tolerances of +/- 1 mm. You will recall that company E uses more clamps in their assembly check fixture than does company D.

Company	% Dimensions C_{pk} <1.33	% Dimensions [Mean] < Tolerance	% Dimensions [Mean] > Tolerance
D	84%	52%	6%
E	38%	75%	6%

Table 4. Body Side Assembly Mean Conformance Relative to Tolerance

Using mean conformance at these companies as benchmarks, Table 5 below recommends criteria based on the distribution of mean dimensions across an entire assembly. The recommendation is to limit the percent of out-of-specification sub-assembly dimensions to less than 10% to reduce the potential for major rework during assembly validation.

As with stamping criteria, some inevitable subjectivity is inherent in the decision-making process. For example, vehicle build teams must make some decisions regarding sub-assembly acceptance based on experience. In other words, teams must identify those cases where they believe an adjustment to the assembly tooling may likely improve a dimensional problem as opposed to expensive die rework. On the other hand, if they know that a particular sub-assembly dimension or set of dimensions is likely to create problems in the final build, they should correct the problem before final weld validation. One particular requirement that is difficult to compensate for in assembly relates to parallelism of feature lines for major closure panels. Many functional build evaluators maintain that meeting parallelism requirements in the detail components and after hemming operations is the most critical requirement. This particular example demonstrates the case where failure to meet specification should be addressed prior to any screw-body evaluations.

Build Event	% Dimensions Mean < Tolerance/2	% Dimensions Mean < Tolerance
Screwbody #1	60%	85%
Screwbody #1	70%	95%

Table 5. Sub-assembly Build Goals for Screw-body Evaluations

Benefits of a Functional Build Approach

Most manufacturers implementing a functional build approach consider reducing die rework as the principal advantage. They recognize the tremendous potential cost savings by avoiding unnecessary rework for out-of-specification conditions that do not affect the final body assembly. Functional build has other benefits including:

- Better identification of build issues: using screw-body evaluations, cross-functional engineering teams may identify both design errors and potential design improvements such as longer trim edges or larger clearances.
- Improved measurement point selection: the functional build process helps manufacturers evaluate the effectiveness of assigned measurement dimensions. Empirical studies show that some dimensions may be dropped from checking routines if they have no effect on the build.
- Increased body development memory: the formal functional build review process allows for a central information database to capture critical build issues for future programs.

Future of Functional Build

This report presents a new paradigm for body validation. Manufacturers that continue to embrace new methodologies and business practices not only will remain competitive in the global market but also establish the benchmark for the competition. By using an integrated validation approach like functional build, manufacturers may accelerate the product development cycle while saving costs in manufacturing process development.

An important issue facing functional build manufacturers is its future application. Functional build involves an additional validation step to construct screw-body prototypes, and it requires greater coordination between development functions. Several manufacturers using functional build aim to eventually develop the manufacturing knowledge necessary to identify when rework is value-added without having to construct screw-body prototype assemblies. The goal is to replace these prototypes with process simulation or math-based functional build. Even with this approach, two fundamental principles behind functional build will remain. First, manufacturers should never rely solely on statistical indices to make tooling and validation decisions. Incorporating process knowledge with dimensional data results in more effective decisions than those based purely on quantitative results. Second, development functions must integrate their product/process knowledge and focus on the final customer product, not necessarily individual components.

AK Steel Corporation

Bethlehem Steel Corporation

DaimlerChrysler Corporation

Dofasco Inc.

Ford Motor Company

General Motors Corporation

Ispat/Inland Inc.

LTV Steel Company

National Steel Corporation

Rouge Steel Company

Stelco Inc.

U.S. Steel Group, a Unit of USX Corporation

WCI Steel, Inc.

Weirton Steel Corporation

Auto/Steel Partnership

This publication was prepared by:

Body Systems Analysis Project Team
The Auto/Steel Partnership Program

2000 Town Center, Suite 320
Southfield, Michigan 48075-1123
248.356.8511 fax
http://www.a-sp.org

A/SP-9030-1 0100 1M PROG
Printed in U.S.A.