



Thermoplastic Injection Mold Process Standard Requirements

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This standard describes the process requirements to identify, understand, correct, and diagnose injection molding process issues. The purpose of these requirements is to logically identify post molding conditions and/or existing conditions that are impeding or slowing the desired process. This standard applies to injection mold tooling, equipment, resin materials, tooling materials, and molding processing parameters. Any deviations from this specification will need to be approved by a representative of the supplier and GM's Bill of Material (BOM) Family Owner (BFO), Supplier Quality Engineer (SQE) and Purchasing Agent using the Deviation Request Form in Appendix A. If applicable, refer to the Appendix E8 of the Statement of Requirements (SOR) for additional injection molding specification requirements.

1.2 Applicability. Injection molded thermoplastic molded parts and assemblies.

1.3 Remarks. This specification is intended to reduce and/or eliminate issues/concerns that a supplier may incur in processing injection molded parts and assemblies; or that a supplier tool maker may incur in creating or correcting tooling conditions. While this specification details the requirements for global qualification, additional information and/or qualification may be requested by GM regional SQE representatives. Additional data required to be submitted will be determined by the regional SQE representatives. Addressed in this specification are the following:

- Tool construction
- Mold design
- T1 Tryout
- Mold performance
- Injection press performance
- Process control
- Process monitoring
- Tool maintenance
- Cooling, mold action, hot runner check
- Design of Experiment (DOE)
- Temperature, material, equipment
- GMW17406 Chrome Plated Plastic Parts Process
- GMW17407 Vehicle Exterior Painted Plastic Add on Parts Process

1.4 Requirement Wording Conventions. Within this specification the following conventions are applied:

- The word "shall" states a binding requirement which verifiable proof shall be provided to GM within 24 h upon request.
- The word "Should" denotes a preference or desired conformance.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

January 2017

Page 1 of 16

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

AIAG CQI-23

AIAG FMEA-4

AIAG PPAP-4

2.2 GM Standards/Specifications.

GMW3059

GMW17044

GMW17406

GMW17407

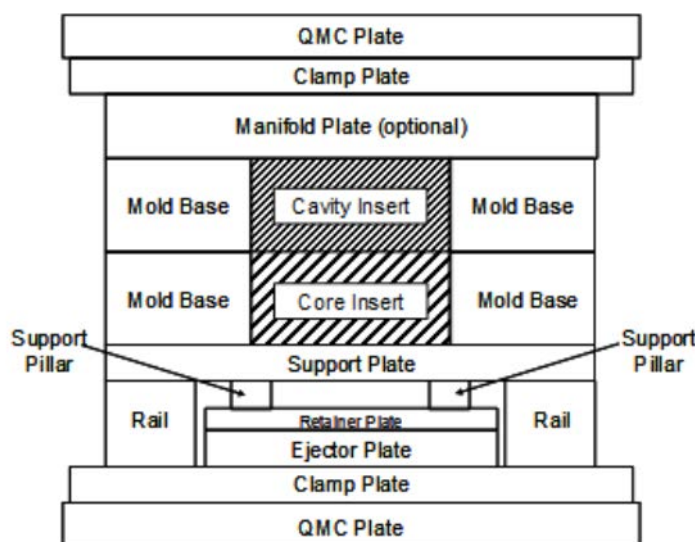
GMW16365

2.3 Additional References.

- Automotive Industry Action Group (AIAG) Failure Mode and Effects Analysis (FMEA) FMEA-4 and Production Part Approval Process (PPAP) PPAP-4, CQI-23 – Special Process: Molding System Assessment are available at Uniform Resource Locator (URL): www.aiag.org.
- Dynisco Injection Molders Handbook, 1st Edition available at URL: www.amazon.com
- Flow Analysis of Injection Molds, 2nd Edition available at URL: www.amazon.com
- GM 1927-16b Injection Molding Audit available at GM SupplyPower at URL: <https://gmsupplypower.covisint.com/>
- GM 1927-28 Early Production Containment available at URL: <https://gmsupplypower.covisint.com/web/portal/home>
- Machinist Handbook, 24th Edition available at URL: www.amazon.com
- Material Specs for Injection Molds, 7th Edition available at URL: www.amazon.com
- Performance Specs for Thermoplastics, 4th Edition available at URL: www.amazon.com
- Process Control Plan
- Statement of Requirements (SOR)
- SOR Appendix E8

3 Requirements

3.1 Tool Construction. See Figure 1.



Note: QMC = Quick Mold Change.

Figure 1: Typical Injection Tool example – High Volume

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

January 2017

Page 2 of 16



Documents

Document Sharing Hub

3.1.1 Mold Specification/Requirements. The supplier (working with the tool build source) shall provide original intent concerning mold specifications/requirements including:

- Press Specifications: Press size, press manufacturer, press age, press performance; all per manufacturer press specifications
- Processing Information: Cycle time, target melt temperature, fill time, recommended mold coolant temperatures (cavity, core, and large actions or inserts if applicable).
- Material Specification: Shrink rate, melt index, manufacturer, grade, supplier, alternative materials considered equivalent that have passed Automotive Industry Action Group (AIAG) Production Part Approval Process (PPAP) PPAP-4 (or equivalent) available at Uniform Resource Locator (URL): www.aiag.org.

3.1.2 Mold Flow. The supplier (working with the tool build source) shall provide original Mold Flow analysis including:

- Gate Locations: Number of gates and locations
- Runner System: Manufacture and runner design
- Fill Pattern: Completed fill with identified hot areas including temperatures
- Cooling Analysis: Analyze as part of cycle time, overall cycle time, and cooling efficiency
- Warp Analysis: Warp identified and reasons detailed
- Cycle Time: Compared to quoted cost cycle time
- Mold Flow Acceptability: Determine if results are acceptable/approved by team
- Mold Flow Completed Date
- Mold Flow Approval Date: The supplier and tool shop, GM Engineering

3.1.3 Mold Design. The supplier (working with the tool build source) shall provide original Three Dimensional (3D) tool and part design data and Two Dimensional (2D) layout prints if available:

- 3D Tool Design Data: Including all plate sizes and configuration, core inserts, cavity inserts, ejection pins/sleeves, moving blocks, wear plates, ejection box, coolant line size and location, purchased components, hot runner system with manufacturer identifier number, overall tool size, overall tool weight, moving side weight, stationary side weight, tool design approval and date approved.
- 3D Part Design Data: Including availability to show wall thickness, undercuts, screw bosses, ribs, cosmetic features, spline and B-spline curves, snap features, core through holes in line of draw, core through holes using lifters, slides, and core pull out of line of draw, part weight with designated material, part surface area, part projected area, part material specific gravity, part design approval and date approved.
- 3D Tool Sequence: The supplier and tool shop shall provide the original intent of the tool sequence and overall operation of the tool. This can be done graphically using 3D Computer Aided Design (CAD) or using video imaging. The tool sequence determines original intent of operation, and original operating performance. The difference between original operation and current operation determines exact area tool performance issues occur.

3.1.4 Mold Action and Slides. The supplier and tool shop shall provide original design and operation of all moving slides and all tool action.

This includes the distance of original travel, and original shut off point. The surfaces of both Tool surface and Tool action surface shall be inspected for premature wear. Original steel dimensions shall be used to check wear surfaces for actual amount of wear realized. Wear plates need to be inspected for premature gouges or cracking to determine if action path is credible, or in need of adjustment or replacement. The operator shall determine if sufficient amount of grease has been used over the entire production time of the tool, or has grease been added most recently. Check grease for translucent areas vs. opaque black areas, Opaque black areas on slides, lifters and adjacent wear plates is a sign the grease has been used over time.

3.1.5 Mold Cooling. The supplier and tool shop shall provide original design and operation of all cooling system information. This includes: coolant line distance to molding surface, coolant line diameter, connection size, bubblers used and size, number of separate coolant circuits, number of potential circuits that can be used, coolant temperature in °C or °F, flow rate through tool.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

January 2017

Page 3 of 16



Documents
Document Sharing Hub

The cooling system shall be completely flushed with chemicals to clean residue and build up off coolant line surfaces internally. The residue build up will act as an insulator and prevent heat conductivity. The coolant system shall then be tested for flow rate using a flow meter. The amount of coolant going into tool shall be restricted by no more than 10% coming out of tool adequate to ensure turbulent flow via Reynolds Number calculation, as follows, and inlet and outlet Temperature Difference (ΔT) should be no larger than 2 °C:

$$N_R = \frac{VD\rho}{\eta} = \frac{VD}{\nu}$$

Where:

N_R = Reynolds Number

V = Velocity of flow (m/s)

D = Diameter of pipe (m)

ρ = Density of coolant (kg/m³)

η = Dynamic Viscosity (kg/m·s)

ν = Kinematic Viscosity (m²/s)

Note: Then units are considered, the Reynolds Number is dimensionless. The Reynolds Number is directly proportional to velocity and inversely proportional to viscosity. For laminar flow, $N_R < 2000$. For turbulent flow, $N_R > 4000$.

The tool design shall identify the bubbler system (if applicable) concerning the bubbler diameter size vs. the diameter of steel opening. The bubbler manufacturer will have size specification for each bubbler size. The steel opening shall be checked for proper diameter size. The bubbler will also have a depth requirement, and should have 9.525 mm ($\frac{3}{8}$ in) to 15.875 mm ($\frac{5}{8}$ in) of coolant space between the tip of the bubbler and the top of steel opening.

The coolant temperature of the tool shall be determined and compared to original process sheet for temperature comparison. The coolant source shall supply treated coolant, and be supplied by either tower coolant, city utilities, or ground coolant. The source of coolant temperature needs to be determined being either by the use of a coolant chiller system, or untreated temperature coolant. The coolant temperature maintained resides between 21 °C (70 °F) and 29 °C (85 °F) for most injection mold systems.

The coolant medium in most cases is water, which may be passed through a temperature control device or used at ambient if doing so results in the desired mold coolant temperatures. If a temperature control device, such as a thermolator is used, it should be in sound working order, free of leaks, and suitable for the chosen medium.

3.2 T1 Tryout.

3.2.1 Mold Check. The supplier and T1 Tryout shop shall be prepared to thoroughly check the tool before the initial mold trial.

3.2.1.1 The coolant lines need to be checked for proper connections, routing and hardware.

3.2.1.2 The coolant lines need to be checked for leakage from lines, connections, injection tool, and injection press. The coolant flow circulation check is to be completed before trial. The coolant circulation test is done when the tool has in and out coolant lines completely connected, and the coolant is circulating through the tool in open mold position. The surface steel temperature on the inside of both the core and the cavity should be checked and compared to coolant circulator temperature.

3.2.1.3 The ejection system needs to be sequenced and "Dry Cycled" to prove the ejection system effectiveness. The dry cycle will determine ejector pin stroke without crashing into other side of tool, or not coming out far enough. Since each injection press can be a different setup, the amount of ejector stroke distance can vary.

3.2.1.4 The trial should be conducted as the original trial that was completed when the tool was first built. The supplier or tool shop shall provide an original tool process sheet. The process variables shall be the same as the original trial completed when the tool was first built. The original process sheet shall have:

- Hot runner system setting

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

January 2017

Page 4 of 16



Documents

Document Sharing Hub

- Machine nozzle setting
- Machine barrel setting
- Actual plastic temperature as measured with insertion probe
- Pack/hold pressure setting with pressures given in terms of actual pressure (hydraulic x intensification ratio)
- Pack/hold time setting
- Fill time
- Injection velocity profile (if any) in cubic units/second
- Peak plastic (hydraulic x intensification ratio) pressure during injection (this should never hit the set high limit)
- Actual steel temperature measured with contact probe
- Resin material manufacturer
- Material grade
- Shrink rate
- Melt index
- Total cycle time
- Trial date and location

3.2.1.5 Perform a **Cavity Balance Study** if two (2) or more cavities are identical or mirrored (Left Hand (LH) to Right Hand (RH)).

3.2.1.6 Perform an **In-mold Rheology (Fill Pressure) Study** to determine an acceptable fill time range.

3.2.1.7 Perform a **Pressure Loss Study** to identify melt delivery system restrictions that need to be corrected.

3.2.1.8 Perform a **Gate Freeze Study** to determine the time required for gate freeze so the part is properly packed out.

3.2.2 Perform an **Injection Mold Analysis Correlation** to compare simulation results with actual molding results to improve future simulations. See GMW16365 Thermoplastic Injection Mold T1 Tryout Protocol.

3.2.2.1 The injection mold shall be compatible with the injection press concerning the temperature settings, material specification, process setting, and tool size verification.

The temperature setting from the injection press shall be compatible with hot runner system (manifold) on the injection mold. If necessary, an auxiliary temperature controller may be required for the tool manifold. The temperature controller controls the temperature setting for all zones of the injection tool including:

- Hot runner nozzle
- Primary manifold zone
- Secondary manifold zone

The material specification shall be followed for temperature setting in hot runner system, controlled by stand-alone temperature controller unit. The injection press shall then be temperature controlled for the nozzle, barrel, and pre-heat zones which are controlled from the injection press control panel.

The process setting has been established through original or prior trials, and is stored in the injection press memory accessed through control panel. Each GM tool trial shop has an established system to recover process sheets based on customer name and identification number. The process setting, once established, shall be locked out so that can only be changed/adjusted by authorized personnel.

Once established, the process shall not be changed or adjusted by anyone but "authorized personnel" and any such changes shall be recorded along with the date and reasons for them. The definition of "authorized personnel" shall be discussed and agreed upon with GM SQE representative. The change log shall be kept for the life of the tool and made ready for review when requested.

The tool shall be verified for size and weight before being placed into the injection press. The dedicated injection press shall be of the capacity in weight and size to accommodate the injection mold. The mold shall fit well within the platens, and never be in an overlap condition. See Figure 2, Figure 3 and Figure 4.

GM Confidential

© Copyright 2017 General Motors Company All Rights Reserved

January 2017

Page 5 of 16