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Oracle Sheet Metal and Plastic Tooling Requirements Specification and Guidelines

Document Number and Revision:	*923-3404 rev 04*

Overview

The purpose of this specification is to document requirements and guidelines for use in the specification, quoting, design, manufacture and approval of sheet metal presswork tools and injection molds.

Use the Oracle Sheet metal Tool Specification Form, 913-3566, and the Oracle Plastic Tool Specification Form, 913-3565, to document the type of tooling the fabricator/molder and toolmaker are proposing, with the understanding that these forms do not encompass all of the design and build categories.

Oracle expects sheet metal tool design, mold design recommendations, and part design suggestions that will improve part cost, tool cost and tool life.

Audience

All Oracle Design and Operations Engineering personnel.

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1 Sheet Metal Tooling Specifications

1.1 General Tool Design Requirements

- Refer to Appendix A, Sheet metal Default Tolerances, on page 21, for additional information on design tolerances.
- Strip layouts, process plans and final tool designs must be reviewed and approved by Oracle tooling representative prior to tool construction.
- Tool designs to be created in CAD, submitted to Oracle in electronic format. ProE, IGES and DXF accepted.
- Tool designs must consist of a punch and die plan view, strip layout, and detailed designs on all die sections, piercing, blanking, forming punches.
- All tools must be safe to handle and conform to OSHA regulations.
- The fabricator and related tool maker is responsible for identifying those tolerances and features that cannot be achieved, prior to commencing tool build
- The Oracle Sheet metal Tool Specification Form, 913-3566-xx, must accompany all quotes, tool purchase orders, and details filled out by the responsible fabricator.

- The fabricator and tool supplier are responsible for flat blank development. The Oracle flat blank drawing (when supplied) is for reference only.
- Tools should be designed and built according to the 3D database and 2D drawing. Part drawings contain critical to function dimensions. Unless otherwise noted on the drawing, the tooling should be designed, built and qualified to the database and comply with 2D dimensioned drawing tolerances and default database tolerances.
- Tool build schedules and updates are required weekly

1.2 General Design Requirements

- Tool quote price should include cost of design and fabrication of tools along with full qualification of tools and parts as described in this specification. Packaging and delivery of tools should also be included in quote. The detailed design and construction of the tooling along with the tool repeatability, process capability and tool life will be the sole responsibility of the fabricator.
- Basic die protection is required to prevent tool breakage due to misfeed, part ejection problems, feeding inaccuracies, part positioning errors. • Progressive strip locating pilot holes should be placed in the scrap carrier where possible. Locations in the part must be agreed to by Oracle.
- All parts and progressions should be located positively, with attention to ease of positioning, removal, and “fool-proofing”. Multiple die sets must use the same location on the part for alignment.
- Die stop/set blocks required for accurate die set-up. • Lifters and other methods of feeding material through the dies should be sufficient and coated to prevent scratches or harm to the pre-plated coated steel. Provide adequate lifters to eliminate any part surface or edge damage.
- All screws, dowels, pins, and other assembly hardware must be standard. • Notching, forming and cutoff sections should be keyed, heeled, or set in the die shoe.
- All components must be fully accessible, maintained. No blind dowels or inaccessible inserts.
- Forming and embossing sections should be removable and adjustable while in the press, for ease of adjustment. Mount tool components for in press removal.
- Spring loaded strippers are preferred over individual ejector pins. Ejector pins must be sufficient diameter to prevent distortion and visible mark.
- High maintenance punch and die sections should be designed with hardened inserts that can be easily replaced as they wear, without sacrificing adjacent tool sections. Provide inserts for weak punch and die sections.
- Standard “off the shelf” die shoes, springs, guide pins and bushings, punches, die bushings and other tool components are preferred.
- Where possible, separate piercing and blanking stations from form stations to allow easier set-up and maintenance.
- Designed in mismatches are preferred over multiple hit edges. Mismatches must be approved by Oracle Engineering.
- Parallels should be of sufficient quantity and location so as to protect cutting and forming stations.

- Piercing stations should be properly placed and separated to minimize “thin steel conditions”. Consideration given to complex piercings that should be staged between a number of progressions or tools.
- Set is required on all forms, preferably on inside surfaces. Pre-scoring is acceptable but must be approved by Oracle Engineering • Separate cut-off and form dies where possible. When tools cut-off and form, the cut-off section must be able to be maintained without redressing the form.
- Use four-post, all steel precision die sets wherever possible.

1.3 Standard Tool Classifications and Design Requirements

1.3.1 Class A Tool Requirements

- Life expectancy of tool is guaranteed a minimum of 1,000,000 hits before additional tool maintenance charges are incurred by Oracle.
- Spare punch and die sections available as agreed upon by Oracle and tool supplier.
- Tool construction allows for ease of assembly and adjustment in the press.
- Die set shall be at least 2" thick, top and bottom, 4 post precision set.
- Die Steel shall be at least 1.25" thick, D-2 or equivalent tool steel, Rc 60 to 62.
- Punches are normal length 2.0", D2 or equivalent tool steel, Rc 60 to 62.
- Strippers shall be at least .75" thick, hardened and guided.
- Punch Holder shall be at least .75" thick.
- Stock guides shall be hardened.
- Designed shall be fully automatic, complete with part sensors, feeding sensors, etc

1.3.2 Class B Tool Requirements

- Life expectancy of tool is guaranteed a minimum of 400,000 hits before additional tool maintenance charges are incurred by Oracle.
- Spare punch and die sections available as agreed upon by Oracle and tool supplier.
- Tool construction allows for ease of assembly and adjustment in the press.
- Die set should be at least 2" thick, top and bottom, 4 post precision set.
- Die Steel is 1.00" thick, D-2 or equivalent tool steel, Rc 60 to 62.
- Punches are at least 1.75", D2, A2 or equivalent tool steel, Rc 60 to 62.
- Strippers are at least .625" thick.
- Punch holders are .75" thick.
- Stock guides hardened.
- Part sensors, feeding sensors, etc. as agreed to with Oracle tooling representative.

1.3.3 Class C Tool Requirements

- Life expectancy of tool is guaranteed a minimum of 100,000 hits before additional tool maintenance charges are incurred by Oracle.
- Die set should be at least 1.5 " thick, top and bottom.
- Die Steel is .75" thick, D-2 or equivalent.
- Punches are at least 1.50" long, A2 or equivalent.
- Strippers are .50" thick.
- Punch Holder .625" thick.
- Stock guides hardened.
- Part sensors, feeding sensors, etc. as agreed to with Oracle tooling representative.

1.4 Tool Approval

- Tool trials will be conducted on production presses at the supplier's site, under production settings with equivalent production materials as specified on the drawing.
- Trial will constitute production process, including multiple die gang set-up.
- All tools must be capable of producing an acceptable part. Tooling should be designed and built to consume no more than 33% of the total part print tolerance for all critical to function dimensions (CTF) and 50% of all other dimensions noted on the 2D drawings as well as implied 3D database feature dimensions.
- All tools are to be marked with Oracle, part number, project number, press tonnage, shut height, tool weight, and feed pitch (if required).
- Detailed tool drawings and CAD files complete and submitted.
- All punch and die sections should have sufficient detail to the extent that new sections are required.
- *Oracle Sheet metal Tool Specification Form*, 913- 3566-xx, completed and signed.
- Tool / Part Supplier completes inspection on parts with all discrepancies corrected prior to final FAI submission to Oracle.
- FAI report is submitted and approved by Engineering.
- SPC dimensions identified and documented by the Fabricator. • Five pieces from FAI and Cpk study are provided to Oracle Engineering and remain the property of Oracle.
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1.5 Part Sample Approval Process

1.5.1 First Article Inspection

The First Article Inspection (FAI) consists of the following five elements:

1. 100% inspection on two flat pattern blanks, either blank, stage or prog. Strip.

NOTE: This data does not need to be submitted with the FAI report. Only five (5) measurements from FAI samples on the 2D print CTFs must be submitted on the FAI report. Refer to WWOPS SPARC Operations Engineering: Tooling Design, Qualification, and Part Approval Process, 923-3402-xx.

Data shall include:

- Formal record capturing all feature dimensions, verified against Oracle 3D database and 2D drawing.
- All feature locations from datum or external edge, verified against vendor tooling layout, and/or Oracle 2D drawing and 3D CAD file formed part (5 pieces).
- X and Y lead in dimensions from the specified datum or edge in each plane
- All bend dimensions
- Angularity of bends
- All formed features for size and location from the datum
- All special tolerance features and CTF dimensions noted on 2D drawing
- All secondary operations, welding, finish, screening, coining, part number stamping.
- All other notes specified on the drawing, ie, burr direction, safe edges, etc.

2. Thirty (30) piece capability study for process variability. The fabricator shall identify and document functional SPC dimensions to be used in the FAI process capability (cpk) study and at statistical process control during production. Cps and Cpks of 1.33 is required.

3. Process Quality Control Plan including inspection attributes, frequency, and method of inspection.

4. Process FMEA submission

5. Related material and process certifications.

6. CPK report including all 30 piece measurement data on all CFT dimensions must be submitted to Oracle and Prime Manufacturer for tool approval.

1.5.2 First Article Inspection Submittal Documentation

Refer to Tooling Design, Qualification, and Part Approval Process, 923-3402.

1.6 Tool Design and Construction Checklist

1.6.1 Tool Design Checklist

Table 1-1 Sample Tool Design Checklist

Ref.	Requirement	Acceptable? (Y/N)
1	Spare punch and die sections identified based on wear, potential damage	
2	Part locators, piloting, “mistake proofing” identified and agreed to by Oracle Engineering	
3	Proper gaging, stock pushers, placed according to part requirements	
4	Tool construction and classification as specified on Oracle Sheetmetal Tool Specification Form, 913-3566	
5	Type and thickness of tool steels verified	
6	Part locators in all stations, sufficient size, location. Will not affect part function	
7	Critical feature to feature dimensions identified and located in single station where possible	
8	Coining identified	
9	Punch, burr direction identified	
10	2D drawing and default tolerances reviewed and agreed upon	
11	Internal radii reviewed	
12	Cut-off and/or mismatch cuts engineered, identified and approve	
13	Critical features requiring piercing after forming identified and achievable	
14	Over 90 degree bends identified	
15	Minimum punch size, bend relief, punch diameters, identified	
16	Methods of ejecting/stripping reviewed and accepted	
17	Die protection discussed, agreed upo	
18	Part identification inserts located properly	

1.6.2 Tool l Check List

Table 1-1 Sample Tool Design Checklist

Ref.	Requirement	Acceptable? (Y/N)
1	Tools stamped with Oracle part number and all other related information	
2	Tools run automatic, semi-automatic, manual load and unload as specified	
3	Part sensors present and function as specified	
4	Production rate (pcs per hour) verified	
5	Detailed tool designs completed and available with the fabricator	
6	Basic die safety considerations included in tooling	
7	Cut edge and “coining” features acceptable and within Oracle guidelines	
8	Bend lines and bend “set” impressions acceptable	
9	All forms bottom out, dimensionally correct	
10	High wear, high maintenance areas were inserted	
11	Forms are adjustable in press	
12	Lifters carry part through progressions without affecting part/surface quality	
13	Tools run in specified presses, production process capable	
14	Part identification correct and visible	

2 Plastic Tooling Specifications

2.1 General Mold Design Requirements

- Final mold designs must be reviewed and approved by Oracle tooling representative prior to tool construction.
- Tool designs to be created in CAD, submitted to Oracle in electronic format. ProE, IGES and DXF accepted.
- Tool designs must consist of a mold plan view, side view and end view, showing all mold details including water lines, gating system, ejection system, parting line, core and cavity details, slide and lifter details.
- All tools must be safe to handle and conform to OSHA regulations.
- The molder and related tool maker are responsible for identifying those tolerances and features that cannot be achieved, prior to commencing mold build.
- The Oracle Plastic Tool Specification Form, 913-3565, must accompany all quotes and tool purchase orders, details filled out by the responsible molder/toolmaker.
- The molder and toolmaker are responsible for calculating shrink factors based on the specified material and part geometry and tolerances.
- Tools should be designed and built according to the 3D database and 2D drawing. Part drawings contain critical to function dimensions. Unless otherwise noted on the drawing, the tooling should be designed, built and qualified to the database and comply with 2D dimensioned drawing tolerances and attached default database tolerances.
- Tool status reports, including the Gantt chart that shows tool progress, should be provided bi-weekly.

2.2 General Design Requirements

- Mold quote price should include cost of design, fabrication, texturing and finish on tools along with full qualification of molds and parts as described in this specification. Packaging and delivery of tools should also be included in quote. The detailed design and construction of the tooling along with tool repeatability, process capability and tool life will be the sole responsibility of the molder.
- Tools should be designed and built to run fully automatic, without damage to parts
- All cavities should be numbered. • Plating cores and cavities must be approved by Oracle Engineering.
- • No welding shall be permissible on visible surfaces of the mold insert that may affect part surface quality, unless approved by Oracle.
- • Use S7, A2 or M2 type tool steels on high production small parts, 52Rc minimum.
- Use H-13 or stainless steel tooling on corrosive materials and larger parts.
- Pre-hard steels must be approved by Oracle.
- All multi-cavity and family molds should be balanced
- Family molds are acceptable on Prototype tooling. Production family molds must be approved by Oracle.
- Eliminate the need for off center sprue bushings where possible.

- Utilize standard DME, Hasco, and Progressive type mold bases and mold components
- Non-standard or custom mold bases and components should be supported by detailed documentation.
- Maximum amount of water should be employed. Manifold where possible.
- Use recessed water fittings that install inside the mold surface when possible
- Use industry standard sprue bushings, 4" dia locating ring, SPE/SPI knock-out patterns.
- 4 parting line interlocks are recommended on all molds. Angles based on steel by passes • Provide automatic de-gating in the tooling where possible.
- Insert tight tolerance, long standing core features. Insert thin steel sections. Insert snap fit, and other “test to fit” features. Insert where necessary
- Provide “steel safe” conditions when requested by Oracle.
- Four (4) guide pins and bushings are recommended on all ejector housings.
- Recess knock-out pins in the surface of the part where permissible (.1mm recess).
- Utilize mold filling analysis to predict weld lines, stress and warpage on complex parts.
- Texture after part has been sampled and approved.
- Cavity steel to be textured should be cut from the same block.
- Blade ejectors are preferred on thin sections.
- Sleeve ejectors are preferred on deep bosses.
- Where possible, avoid use of ejectors on external cavity wall.
- Slides should be cammed with angle pins and retained by heel blocks.
- Mold surfaces should comply with surface finishes specified on the drawing.

2.3 Standard Mold Classifications and Design Requirements

Table 2-1 and Table 2-2 provide mold-specific information based on Oracle expectations for mold lifetime cycles. The mold design requirements in this section are recommendations and should be considered during the mold quoting, design and build cycle based on the forecasted mold life provided by Oracle.

Table 2-1 Mold Types and Classes

Mold Class	Mold Type	Mold Life
1	Very High Production Mold	500,000 to 1,000,000 pcs
2	High Production Mold	250,000 to 500,000 pcs
3	Medium Production Mold	100,000 to 250,000 pcs
4	Low Production Mold	10,000 to 100,000 pcs
5	Prototype Molds for Pre-Production Build	1000 to 5000 pcs

Table 2-2 Mold Classifications

Mold Classifications					
Mold Design Guidelines	***1***	***2***	***3***	***4***	***5***
Tool Steel Cavity Inserts	*X*	*X*	*X*		
Tool Steel Core Inserts	*X*	*X*	*X*		
Pre-Hard Cavity Inserts		*X*	*X*	*X*	
Pre-Hard Core Inserts		*X*	*X*	*X*	
Cavities cut in A Plate			*X*	*X*	*X*
Cavities cut in B Plate			*X*	*X*	*X*
Stainless Steel Frame	*X*				
Stainless Steel Water Plates	*X*	*X*			
Nickel Plated Water Plates		*X*			
AISI 4130 Mold Base or better		*X*	*X*	*X*	
Pre-Hard Prototype Inserts					*X*
Aluminum Inserts					*X*
Aluminum Cavity and Core A/B Plates					*X*
Dedicated Mold Frame	*X*	*X*	*X*	*X*	
Standard Mold Base				*X*	*X*
Automatic Side Action	*X*	*X*	*X*	*X*	
Manual Load Inserts					*X*
Full Mold Design Detains	*X*	*X*	*X*	*X*	
Simple Mold Plan Layout					*X*

2.4 Mold Approval

- Mold trials will be conducted on production presses at the supplier's site, under production settings with equivalent production materials as specified on the drawing.
- All molds must be capable of producing an acceptable part. Tooling should be designed and built to consume no more than 33% of the total part print tolerance for all critical to function dimensions (CTF) and 50% of all other dimensions noted on the 2D drawings as well as implied 3D database feature dimensions.
- All molds are to be marked with Oracle, part number, project number, press tonnage, tool weight. Install asset tag where applicable
- Process sheet documenting temperature, pressure, time, shot size and other pertinent information shall be required at time of tool approval.
- Detailed mold drawings and CAD files complete and submitted.
- All core and cavity sections should have sufficient detail to the extent that new sections are required.
- *Oracle Plastic Tool Specification Form*, 913- 3565, reviewed.
- Molder completes inspection on parts with all discrepancies corrected prior to final FAI submission to Oracle.
- FAI report is submitted and approved by Engineering
- SPC dimensions identified and documented by the molder.

2.5 Part Sample Approval Process

2.5.1 First Article Inspection (CMM)

The FAI shall consist of the following five elements:

1. 100% inspection of the following features on 2 parts, using production molding machines, processes and tooling. 5 piece inspection on all out of spec conditions, performed by the supplier for all items listed. This data does not need to be submitted with the First Article Inspection (FAI) Report. Only five (5) measurements from FAI samples on the 2D print CTFs must be submitted on the FAI report. Refer to WWOPS SPARC Operations Engineering: Tooling Design, Qualification, and Part Approval Process, 923-3402.

Data shall include:

- Overall width, length, height and nominal wall as required
- All Boss I.D.s and functional cutouts; size and location, measured from the primary, secondary and tertiary datums
- External and internal threads as required
- All critical to function dimensions indicated on the drawing
- All secondary operations, heat staking, assembly, decorating, etc
- Texture, sink marks, gate vestige, ejector pin height, flow marks, etc
- All other notes specified on the drawing

2. Thirty (30) pc capability study for process variability. The Molder shall identify and document functional SPC dimensions to be used in the FAI process capability (cpk) study and at statistical process control during production. Cps and Cpks of 1.33 is required; Oracle Supplier Engineer to approve SPC dimensions and process plan.

3. Process Quality Control Plan including inspection attributes, frequency of inspection, etc.

4. Related material and process certifications.

2.5.2 FAI Submittal Documentation

Refer to Tooling Design, Qualification, and Part Approval Process, 923-3402.

2.6 Tool Design and Construction Checklist

2.6.1 Tool Design Checklist

Table 2-3 Sample Tool Design Checklist

Ref.	Requirement	Acceptable? (Y/N)
1	Tool construction and classification designed according to Oracle Plastic Tool Specification Form, 913-3565	
2	Type of tool steels verified	

3	Critical feature to feature dimensions identifie	
4	2D drawing and default tolerances reviewed and agreed upon	
5	Gate type, gate vestige, and gate placement approved by Engineering	
6	Thin steel conditions reviewed and eliminated where possible	
7	Mold shrinkage discussed and approved	
8	All drafted surfaces considered in mold design	
9	Part ejection type and placement sufficient and approved by Engineerin	
10	Surface finishes and textures reviewed. Draft appropriate for texture	
11	Step parting line and “pass-by” shutoff draft angles reviewed and acceptable	
12	Critical features and surfaces identified as “steel safe” condition	
13	Tight tolerance and “design sensitive” features inserted for ease of chang	
14	Prediction of weld line location, strength, and cosmetic concerns discussed, agreed	
15	Water line placement, quantity, and control, sufficient to cool part evenly	
16	Gate and runner balanced to provide even flow and distribution to part	
17	Flow leaders and restrictors discussed	
18	Part identification inserts located per pricing and Oracle standards	
19	Material regrind considered	
20	Expected part tolerances and possible warpage reviewed, agreed upon	
21	Part and tool design methods to eliminate sink marks, blemishes, have been reviewed	

2.6.2 Tool Checklist

Table 2-4 Sample Tool Checklist

Ref.	Requirement	Acceptable? (Y/N)
1	Tools stamped with Oracle part number and all other related information	
2	Tools run automatic, semi-automatic, manual load and unload as specified	
3	No mold release agents used to assist in part ejection	
4	Production rate (pieces per hour) verified	
5	Detailed tool designs completed and available with the molder	
6	Basic mold safety considerations included in tooling	
7	High wear, high maintenance areas were inserted	
8	Tools run in specified presses, production process capable	
9	Tools conform to the Mold Specification Shee	
10	Part identification correct and visible	
11	Parts eject freely from mold. No noticeable, induced warpage	
12	Verify all cavities are identified	
13	No visible signs of flash due to venting or mold opening	
14	Part conforms to print	

Appendix A Sheet metal Default Tolerances

Hard Tooling

Quality Level: 4 sigma

PPM Defective: 6210

CP = CPK Value: 1.33

Sheet Metal and Plastic Part Design Tolerances

Refer *to Mechanical Tolerance Design Guideline*, 7078298 for a comprehensive list of sheet metal and plastic design tolerances.

Related Information

Reference Documents and Records

Document Title	Number	ESO Controlled	
		Yes	No
Oracle Plastic Tool Specification Form	913-3565		
Oracle Sheet metal Tool Specification Form	913-3566		
WWOPS SPARC Operations Engineering: Tooling Design, Qualification, and Part Approval Process	923-3402		
Mechanical Tolerance Design Guideline	7078298		

Document History and Approvals

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Rev	**Date**		**Description**	**Originator**
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03	15 Jul 2014		Edited content in sections 1.1, 1.5, and 2.5 to reflect current practice	Lea Diagle
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04	Jan 04, 2022		Removed all WWPOS SPARC Operations Engineering: and replaced by Oracle. Updated to Redwood format. No content change.	N/A

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Removed all WWOPS SPARC Operations Engineering: and replaced by Oracle

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