

Invision products are produced in various forms, but all Invision products consist of a primary layer of high melt strength thermoplastic polyolefin (TPO). It is this layer that primarily dictates the forming characteristics of the sheet, with subtle processing changes being required by product type and protective mask applied. The purpose of this guide is to help the user in overcoming problems that may be encountered in thermoforming. Typically, thermoforming problems can be related back to four primary areas: Inadequate process control, incorrect sheet temperature at the time of forming, poor or lack of vacuum control, and insufficient cooling. Refer to this guide for suggested actions to correct or eliminate processing problems. This trouble shooting information will apply across all Invision products. Reference the Invision product data sheets for specific processing conditions by product. Additional technical information is provided in the tooling guide, part design guide, material bonding guide, and painting and repair guides.

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Problem	Probable Causes	Suggested Course of Action
Blister or Bubbles	Sheet heated too quickly	<p>Lower heater's temperatures</p> <p>Use slower heating</p> <p>Increase distance between heaters and sheet</p> <p>Install screening to deflect heat.</p>
	Excessive moisture	<p>Pre-dry material 2 - 4 hours at 150° F</p> <p>Heat material from both sides</p> <p>Lower heater temperatures to allow more soak time</p> <p>Do not allow inventory to age greater than 10 -12 weeks.</p> <p>If possible, store sheet in a temperature controlled area.</p> <p>If moisture proof packaging is provided, do not remove until ready to use and reseal when use is completed, or use all material once the package is opened.</p>
	Uneven Heating	<p>Install screening to deflect heat from localized hot spots</p> <p>Confirm screen location</p> <p>Check heaters for proper operation</p> <p>Adjust heater zones to balance sheet surface temperature</p>
Poor Detail in Formed part	Sheet too cold	<p>Increase dwell time to heat sheet longer</p> <p>Increase temperature of heaters</p> <p>Check heaters for proper operation</p> <p>Pre-heat clamping frame to eliminate heat draw from sheet by cycling machine prior to loading sheet.</p> <p>Increase heat curtain around clamped sheet area with additional heaters.</p> <p>Check for air drafts across sheet due to open doors, fans, etc.</p>
	Insufficient Vacuum or vacuum not drawing fast enough	<p>Adjust vacuum bleed in rate and timing of the vacuum initiation as the tool first contacts sheet.</p> <p>Check for vacuum leaks in tooling seals, lines, equipment, etc.</p> <p>Confirm minimum of 25 inch of Hg when measured at the vacuum box.</p> <p>Confirm proper operation of equipment, valves, pumps, etc.</p> <p>Check vacuum holes for blockages</p> <p>Increase the number of vacuum holes</p> <p>Increase size of vacuum holes (use caution to prevent part read)</p> <p>Increase the size of the vacuum surge tank or vacuum capacity, vacuum lines, valves and eliminate excessive elbows</p>
	Tooling inadequate	<p>Use a frame assist or plug assist to stretch material into areas where poor detail is occurring.</p> <p>Use pinch frame to create seal</p> <p>Use bladder as pressure assist.</p> <p>Air entrapment. Sand blast the mold with #30 shot grit to obtain slight mold texture and/or directionally sand from problem area to vacuum holes.</p>
	Sheet too thick	<p>If feasible, reduce sheet thickness.</p>

Problem	Probable Causes	Suggested Course of Action
Poor formed part detail in pressure forming	Improper pressure	Use 20 - 50 psi (0.137 - 0.345 Mpa) air pressure as measured in pressure forming at the pressure box. Make sure box can hold the pressure. Check for pressure leaks in pressure box, box seal, hoses, etc.
Sheet scorched	Surface of the sheet is too hot	Reduce heating cycle or heating dwell time Lower heater temperature to allow more soak time. Move heaters further away from sheet surface. Check heaters for proper operation.
Blushing or discoloration	Excessive heat	Reduce cycle time. Balance heat to ensure proper formed detail. Reduce heater temperatures, offset with increased dwell time Check heaters/setting if condition is localized, adjust as needed. Lower heater temperatures on high gloss "A" surface. Blow chilled air across high gloss "A" surface.
	Insufficient heat	Lengthen heating dwell time to increase sheet temperature. Increase heater temperature settings to increase sheet temperature.
	Mold is too hot or too cold	Adjust mold temperature. If defect is localized, check for a corresponding hot or cold spot in the mold and correct.
	Plug assist is too cold	Warm assist. Use syntactic foam or cover with flannel or felt.
	Excessive draw on sheet	Use heavier gauge sheet. Change forming method or use plug assist. Change orientation of the mold as mount on base. Change mold design.
	Mold design	Increase the radii or draft angles of the mold. Reduce depth of draw by mold redesign, or use a plug assist.
Whitening of part in corners or across surface in general	Sheet too cold, causing sheet to stretch beyond it's yield point.	Increase sheet heating dwell time Reduce platen time delay Reduce vacuum delay Reduce time between heating and forming sheet. Increase speed of the assist and/or mold travel. Increase temperature of the assist.

Problem	Probable Causes	Suggested Course of Action
Webbing, bridging or wrinkling	Sheet too hot, causing too much material in forming area	Reduce heating time Lower heater temperatures Check heaters for proper operation. Increase distance between sheet and heaters. Screen heaters in areas of excess sag. Use minimal sheet forming temperatures Profile heaters to reduce temperature in areas of webbing, bridging or wrinkling.
	Insufficient vacuum	Check for vacuum leaks in tooling seals, lines, equipment, etc. Confirm minimum of 25 inch of Hg when measured at the vacuum box. Confirm proper operation of equipment, valves, pumps, etc. Check vacuum holes for blockages Increase the number of vacuum holes or use slots instead of holes. Increase size of vacuum holes (use caution to prevent part read) Increase the size of the vacuum surge tank or vacuum capacity, vacuum lines, valves and eliminate excessive elbows
	Vacuum speed too fast	Reduce vacuum rate Adjust vacuum bleed in rate and timing of the vacuum initiation as the tool first contacts sheet.
	Excessive draw ratio or poor mold design	Add take up blocks to pull material away from the corners Use recessed pockets, web moats, in areas of webbing. Increase the draft and radii of the mold design Use a plug or ring assist Use female mold instead of male mold. Increase speed of the assist and/or mold travel. If multiple molds, increase the distance between molds, use part isolators or grids. Redesign grid, plug, or ring assists. Redesign mold or switch to female mold design.
	Insufficient sheet stretching	Drive tool further into clamp frame to stretch sheet.
	Change orientation of sheet.	If possible, change orientation of sheet by 90 degrees within clamp frame.
Nipples on mold side of formed part	Sheet too hot	Reduce heating dwell time. Reduce heater temperatures. Increase time between heating and forming Reduce temperature of sheet surface that contacts mold
	Vacuum holes	Plug vacuum holes and re-drill smaller holes

Problem	Probable Causes	Suggested Course of Action
Excessive sag after heating	Sheet too hot	Reduce heater dwell time. Reduce heater temperatures. Balance sheet temperature to increase perimeter heat, decrease center heat or screen center heater areas.
	Sheet area too large	If available, ensure auto level feature is activated.
Sag variation, sheet to sheet.	Sheet slipping out of frame	Adjust clamping frame to provide uniform clamp pressure. Adjust clamping frame alignment for adequate clamp area. Check for loose, leaking, or kinked air lines on clamp cylinders. Check to make sure clamp cylinders air pressure is adequate. If retainer springs are used, change to higher temper springs. Install screws or grippers in clamp frame. Make sure clamp area is free of debris.
	Material is not uniform	Check for gauge uniformity sheet to sheet.
	Hot or cold spots in sheet.	Maintain a consistent forming cycle. Make sure sheet is heated uniformly. Check heaters for proper operation. Avoid air flow and drafts across sheet. Enclose heating and forming area.
Shiny streaks or spots	Sheet overheated in areas	Reduce heater temperature in the localized areas Screen the localized areas if unable to adjust with heaters Use slower heating cycle. Increase distance between sheet and heaters. Check with sheet material supplier regarding sheet quality.
Shrink marks in corners	Poor vacuum	Adjust vacuum bleed in rate and timing of the vacuum initiation as the tool first contacts sheet. Check for vacuum leaks in tooling seals, lines, equipment, etc. Confirm minimum of 25 inch of Hg when measured at the vacuum box. Confirm proper operation of equipment, valves, pumps, etc. Check vacuum holes for blockages Increase the number of vacuum holes or use slots instead of holes Increase size of vacuum holes (use caution to prevent part read) Increase the size of the vacuum surge tank or vacuum capacity, vacuum lines, valves and eliminate excessive elbows
	Mold surface too smooth	Sand blast the mold with #30 grit to roughen the surface of the mold.
	Part shrinking away from corner	Add moat to mold just outside trim line.

Problem	Probable Causes	Suggested Course of Action
Chill marks or mark off lines	Mold temperature too cold	<p>Increase the mold temperatures if the mold is water cooled.</p> <p>If the mold is not water cooled, cycle the tool to preheat it.</p> <p>Increase the pre-stretch to delay the material contact with the mold.</p> <p>Inspect mold for localized cold areas and correct water flow if needed. Increase water channels or improve flow.</p>
	Mold design	Relieve mold in critical off part areas that may stop sheet formation on part surfaces.
	Plug assist too cold	<p>Increase plug assist temperature.</p> <p>Use syntactic foam plug assist material.</p> <p>Cover plug assist with flannel or felt.</p>
	Insufficient pre-stretch	Increase assist pressure, travel, or time.
	Sheet too hot	<p>Reduce heating dwell time.</p> <p>Reduce heater temperatures.</p> <p>Increase heating dwell time to heat sheet more uniformly.</p> <p>Reduce sheet surface temperature by heater adjustment or use slight amount of forced air on the sheet surface just prior to hot sheet contacting mold.</p>
	Change forming rate	Increase sheet forming rate.
	Sheet sticking to mold	<p>Mold too smooth. Sand blast the mold with #30 shot grit to obtain slight mold texture.</p> <p>Use mold release to reduce coefficient of friction (COF)</p>
	Mold travel excessive	Decrease the distance the mold travels through sheet line.
Part sticking to plug assist	Incorrect plug assist temperature	<p>Reduce plug temperature</p> <p>Use mold release, spray release or permanent release coating, such as Teflon.</p> <p>Cover plug with felt cloth or cotton flannel.</p> <p>Use syntactic foam plug.</p>
	Incorrect plug assist material for sheet type.	<p>Use mold release, spray release or permanent release coating, such as Teflon.</p> <p>Cover plug with felt cloth or cotton flannel.</p> <p>If wooden, wax plug with a paraffin wax.</p> <p>Laminate wood plug surface with syntactic foam.</p> <p>Replace plug assist material with sheet supplier recommended material.</p>

Problem	Probable Causes	Suggested Course of Action
Surface imperfections	Pock marks on smooth mold surface	<p>Air entrapment. Sand blast the mold with #30 shot grit to obtain slight mold texture and/or directionally sand from problem area to vacuum holes.</p> <p>Check for vacuum leaks in tooling seals, lines, equipment, etc.</p> <p>Confirm proper operation of equipment, valves, pumps, etc.</p> <p>Check vacuum holes for blockages</p> <p>Increase the number of vacuum holes or use slots instead of holes</p> <p>Increase size of vacuum holes (use caution to prevent part read)</p> <p>Increase the size of the vacuum surge tank or vacuum capacity</p>
	Dirt on sheet or mold	Clean sheet and or mold surface prior to forming. A de-ionized air gun is recommended to neutralize the sheet surfaces while blowing particulate from the surface.
	Dirt in ambient air	<p>Clean area and reduce tow motor or other traffic within the area</p> <p>Isolate area and if necessary, filter and de-ionize ambient air.</p> <p>Remove granulators or trim cells from area or contain trim cells in an isolated enclosure.</p>
	Water droplets	<p>If using spray mist, decrease use.</p> <p>Check all hoses, gaskets, etc. for leaks and / or condensation.</p>
	Mask imperfections	If used, inspect forming mask for surface imperfections, contamination, or delamination.
	Bad sheet	Inspect sheet for surface imperfections, scratches, dirt, lumps, sinks, carbon specks, voids, flow disturbances, etc.
	Mold is too hot	Reduce mold temperature, or check and correct localized hot spots if surface imperfections are localized
	Mold is too cold	Increase mold temperature.
	Improper mold material construction	<p>Avoid phenolic or other glossy molds with poor thermal conductivity.</p> <p>Use aluminum tooling whenever possible</p>
	Indentations	Mold surface too smooth. Sand blast the mold with #30 shot to obtain slight mold texture.
Mold surface is too rough	<p>Smooth rough/uneven areas and sandblast with #30 shot grit.</p> <p>Change mold material of construction.</p>	

Problem	Probable Causes	Suggested Course of Action
Distortion in part after removing part from the mold	Removing part from the mold too soon.	<p>Increase the cooling time.</p> <p>Use a temperature controlled mold.</p> <p>Use fans or water mist to cool part faster on the mold.</p> <p>If mold is water cooled, check temperature and water flow.</p> <p>Also check mold cooling circuits and modify if needed to eliminate tooling hot spots, such as adding more coolant channels, or increasing flow rate.</p> <p>Increase flow rate by increasing pressure or channel diameter.</p> <p>Inspect coolant flow path for debris, plugging, rust. Flush if necessary.</p>
	Removing part from the mold too fast	<p>Reduce speed of platen</p> <p>Break vacuum between part and tool with pulsed air ejection prior to removing tool.</p>
	Uneven cooling	If mold is water cooled, check temperature and water flow. Also check mold cooling circuits and modify if needed to eliminate tooling hot spots.
	Poor material distribution	Improve material distribution by pre-stretch or plug assist.
	Mold temperature	Lower mold temperature 10 F below HDT of material.
	Inadequate draft or radii or undercuts	Increase draft angles and radii where ever possible and minimize undercuts or use tooling action in to eliminate
	Sticking to the mold.	Use a mold release agent to reduce surface COF between the part and the mold.
Controlling post-forming shrinkage	Time on mold too short	<p>Increase cooling time</p> <p>Ensure tool cooling is adequate.</p> <p>Make sure localized hot spots do not exist.</p> <p>Use cooling fixtures.</p>
	Sheet forming temperature too hot.	Reduce sheet forming temperature. Consult sheet material supplier to ensure forming temperature is not excessively reduced.

Problem	Probable Causes	Suggested Course of Action
Poor wall thickness	Improper sag	<p>Heat sheet uniformly to allow material to flow properly</p> <p>Check sheet gauge uniformity.</p> <p>Mount mold on top platen</p> <p>Improve pre-stretching or plugging techniques</p> <p>Use plug assist.</p> <p>Consider a different forming method or technique</p> <ul style="list-style-type: none"> Vacuum snap-back forming Billow vacuum snap-back method Billow-up plug assist or vacuum snap back into a female tool. <p>If sag is too high, use heater screening in center areas or reduce heater percentages</p>
	Hot or cold spots in sheet.	<p>Balance sheet heating</p> <p>Check heaters for proper operation.</p> <p>Avoid air flow and drafts across sheet. Enclose heating and forming area.</p> <p>Pre-heat clamping frame to eliminate heat draw from sheet by cycling machine prior to loading sheet.</p>
	Mold too cold	<p>Increase mold temperature 10 F below HDT of material.</p> <p>If mold is water cooled, check temperature and water flow. Also check mold cooling circuits and modify if needed to eliminate tooling hot/cold spots.</p> <p>Pre-heat tool to operating temp by cycling machine prior to loading sheet.</p>
	Non-uniform pre-stretch bubble	<p>Uneven sheet gauge across web</p> <p>Heat sheet slower, longer with lower heater temperature settings</p> <p>Uneven heating of sheet due to heater settings or non functioning heaters</p> <p>Check heater screen placement, screen heater as necessary.</p> <p>Enclose, shield, or screen thermoformer oven from drafts</p> <p>Check clamping frame for air leaks</p> <p>Baffle air inlet in pre-stretch box.</p>
	Sheet slipping out of frame	<p>Adjust clamping frame to provide uniform clamp pressure.</p> <p>Check for loose, leaking, or kinked air lines on clamp cylinders.</p> <p>Check to make sure clamp cylinders air pressure is adequate.</p> <p>Check for uniform sheet gauge.</p> <p>Pre-heat clamping frame to eliminate heat draw from sheet by cycling machine prior to loading sheet.</p> <p>Install screws or grippers in clamp frame.</p> <p>Make sure clamp area is free of debris.</p> <p>Make sure sheet is heated uniformly.</p>

Problem	Probable Causes	Suggested Course of Action
Thin corners when forming over a female tool	Improper forming method	Use a billow forming method to pre-stretch the sheet before forming. Use a plug assist and / or pre-stretch.
	Variation in sheet temperature	Profile sheet heating by adjusting heaters or adding screens to maintain sheet going into corners at a cooler temperature than surrounding sheet. Adjust the heating temperatures so the sheet is evenly heated. Increase the perimeter heaters to be higher than the center heaters, in increments of 10% until balance is obtained. Increase the heating area outside the clamp frame to assist achieving sheet temperature balance. Avoid air flow and drafts across sheet. Enclose heating and forming area.
	Sheet too thin	Use heavier gauge sheet.
	Variation in mold temperature.	Inspect mold for localized cold areas and correct water flow if needed. Increase water channels or improve flow.
	Insufficient Vacuum or vacuum not drawing fast enough	Adjust vacuum bleed in rate and timing of the vacuum initiation as the tool first contacts sheet. Check for vacuum leaks in tooling seals, lines, equipment, etc. Confirm minimum of 25 inch of Hg when measured at the vacuum box. Confirm proper operation of equipment, valves, pumps, etc. Check vacuum holes for blockages Increase the number of vacuum holes Increase size of vacuum holes (use caution to prevent part read) Increase the size of the vacuum surge tank or vacuum capacity, vacuum lines, valves and eliminate excessive elbows
Corner cracking in service	Stress concentration	Increase radii Corner too cold during forming Increase mold temperature Increase sheet temperature Increase forming rate Pre-stretch sheet Decrease free surface cooling. Decrease plug rate of penetration
	Sheet too thin	Use heavier gauge sheet.
	Part design	Draw too great. Redesign.

Problem	Probable Causes	Suggested Course of Action
Part sticking to mold	Mold design	<p>Increase the draft angle of the mold.</p> <p>Sand blast the mold with #30 grit to roughen the surface of the mold.</p> <p>Evaluate undercuts. Use breakaway or slide/lifter action in the mold for undercuts or change mold to minimize undercuts</p> <p>Consider use of a stripping frame</p> <p>Increase the air ejection pressure</p> <p>Use a mold release agent to reduce surface COF.</p> <p>If tool is wooden, lubricate with paraffin wax.</p> <p>Use female tool</p> <p>If part sticking is due to material shrinkage onto the male mold, remove part from tool as soon as possible</p>
	Mold or sheet temperature too high	<p>Increase cooling time</p> <p>Decrease sheet temperature, or temperature of sheet surface that contacts the mold</p> <p>Lower mold temperature.</p> <p>Use a temperature controlled mold.</p> <p>Use fans or water mist.</p> <p>If mold is water cooled, check temperature and water flow.</p> <p>Also check mold cooling circuits and modify if needed to eliminate tooling hot spots, such as adding more coolant channels, or increasing flow rate.</p> <p>Increase flow rate by increasing increasing pressure or channel diameter.</p> <p>Inspect coolant flow path for debris, plugging, rust.</p> <p>Flush if necessary.</p>
Tearing of the sheet when forming	Mold design	Increase the radii or draft angles of the mold.
	Sheet too cold	<p>Increase the heating dwell time and sheet temperature.</p> <p>Balance temperature across the sheet.</p>
	Sheet too hot	Decrease heating time or heater temperature.
	Sheet too thin	<p>Use thicker sheet or adjust process or forming method for use of thinner sheet.</p> <p>Increase sheet pre-stretch.</p>
	Vacuum too rapid	<p>Reduce the rate of the vacuum being pulled.</p> <p>Bleed the vacuum slowly.</p>
	Closing speed too high	Reduce the rate of closing speed between the mold and sheet during forming.
	Moisture	Heat sheet more slowly or pre-dry sheet 2 - 4 hrs at 150° F

Problem	Probable Causes	Suggested Course of Action
Part Warpage	Uneven part cooling	<p>If mold is water cooled, check temperature and water flow. Also check mold cooling circuits and modify if needed to eliminate tooling hot spots.</p> <p>Check water flow through tooling.</p> <p>Make sure supply or discharge lines and couplings do not restrict flow. Make sure water pressure is adequate.</p> <p>If tool has multiple zones, make sure zones are plumbed correctly.</p> <p>Cool part evenly on both sides.</p> <p>Consider use of cooling fixtures to cool parts uniformly.</p>
	Part removed from tool too early.	Part must be below sheet material HDT temperature, or "set temperature".
	Mold temperature too low	Raise mold temperature to 10 F below material HDT.
	Uneven sheet heating	In heavy gauge sheet, heat both sides of sheet more uniformly
	Sheet cools too fast during forming.	Increase sheet forming rate
	Mold design	<p>Ensure vacuum is adequate to maintain full sheet contact to mold surface during cooling. See suggestions for Insufficient Vacuum.</p> <p>Add moat to mold at the trim line.</p> <p>Redesign rim area to stiffen.</p>
	Part design	<p>Avoid large flat surfaces.</p> <p>Break up with ribs, style lines, corrugations, etc., whenever practical.</p> <p>Crown large radius areas.</p>
	Poor wall distribution	See causes and remedies for "Poor Wall Thickness"

