COMMON PROBLEMS ENCOUNTERED IN THE EXTRUSION OF PVC AND THEIR SOLUTION

Symptom	Basic Defect	Constructions Normally Exhibiting Defect	Cause of Problem	Immediate Corrective Action: Preferred	Immediate Corrective Action: Alternative	Major Improvements Needed
I. FAILURE OF CONSTRUCTION TO MEET PROPERTY TESTS						
A. Low, variable insulation resistance; low initial elongation.	Strains and microscopic cracks due to strains on the inner and outer surfaces.	Thin-wall primary insulation on small-gauge wire and thin-wall jackets.	Cold conductor or core.	Preheat conductor to 280°F-300°F with electric preheater.	Drastically decrease takeoff speed.	Installation of controllable wire preheater.
B. Low initial tensile properties.	Improperly fused stock.	Heavy-wall jackets.	Improper stock temperature and inadequate working.	Increase stock temperature and working.*		Appropriate redesign of screw.
C. Test failures in: heat shock	Strains due to poor flow in approach to die which cannot relax during cooling of insulation or jacket and/or excessive drawdown.	Thin-wall primary insulation.	Cold conductor. Cold water bath close to die.	See IA.	See IA.	See IA.
heat resistance			Nonstreamline die approach.	Polish and clean surfaces of die and approach.		Replace die and guider with well-streamlined, highly polished die and guider.
soldering						
cold bend			Obstructions in path of flow causing nonstreamline flow.	Remove thermocouples or other obstructions from flow path.		Install thermocouples or other instruments which protrude into path of flow well back in crosshead.
			Oversize die opening requiring high drawdown ratio to maintain size.	Switch to die with opening approximately same size as construction or no more than 5%-8% greater on an area basis.		

*Adjustments to Lower Stock Temperature
Increase space between guider and die.
Decrease screen pack.
Adjust screw cooling.
Lower controlling barrel heat zones and crosshead temperature.

Adjustments to Increase Stock Temperature and Working
Decrease space between guider and die.
Increase screen pack.
Adjust screw cooling.
Raise controlling barrel heat zones and crosshead temperature.

THE GEON COMPANY

The Geon Company / One Geon Center, Avon Lake, Ohio 44012

Symptom	Basic Defect	Constructions Normally Exhibiting Defect	Cause of Problem	Immediate Corrective Action: Preferred	Immediate Corrective Action: Alternative	Major Improvements Needed
II. POROSITY						
A. Voids occurring generally throughout the entire wall of jacket or insulation.	Entrapped air in extruded section.	Heavy-wall jackets and primary insulations.	Melt zone too far forward in barrel to force entrapped air back through hopper.	Increase screen pack — more or finer screens.	Decrease line speed.	Extend barrel length.
			Inadequate screw design for low back-pressure extrusions.	Decrease space between wire guider and die.		Replace screw with shallower flight depth metering section screw.
			Too-large construction for extruder capacity.	Use long land dies. Adjust screw cooling. Raise temperature of controlling barrel heat zones. Preheat feed stock to a constant temperature prior to extrusion.	Switch heavy-wall constructions to larger machines.	
B. Voids occurring normally just beneath outer surface of jacket or insulation, sometimes giving a rough or grainy surface depending on severity of problem.	Moisture in material.	Any construction.	Humid weather and prolonged storage of feed stock in damp locations.	Dry material in hopper dryer installed on extruder.	Dry material in oven.	Installation of hopper dryers.
				Prevent moisture pickup by: 1) Minimizing inventory during humid seasons. 2) Locating storage areas in warm dry locations. 3) Storing materials in tightly closed containers. Move water bath closer to die line.	Reextrusion of wet stock after regrinding to obtain nonporous construction.	Investigation of other means of removing volatiles during extrusion such as vented extruders, etc.

Symptom	Basic Defect	Constructions Normally Exhibiting Defect	Cause of Problem	Immediate Corrective Action		Major Improvements Needed
				Preferred	Alternative	
C. Voids occurring sporadically in wall of jacket or insulation, usually accompanied by chunky surface roughness.	Volatiles from degraded stock in extruded section, e.g., HCl gas from degradation of PVC.	Any construction, but especially a multiple-conductor construction requiring a complete die design.	Excessive stock temperature.	Lower temperature of controlling barrel heat zones and crosshead. Decrease screen pack – fewer or coarser screens. 1-40 and 1-60 minimum screen pack recommended. Adjust screw cooling. Increase space between wire guider and die.	Decrease speed.	Possible need for more-effective temperature controls. Possible need for replacing screw with one of proper design.
			Extended runs without cleanouts or screen changes.	For extended runs without adequate shutdowns for cleanouts, maintain stock temperature under 380°F. Provide for screen change at least every eight hours.		
			Poor streamlining or flow in approach and crosshead.	Decrease crosshead temperature.		Redesign dies, guiders, breaker plates, and approaches with smooth angles and good streamlining.
			Dirty or pitted dies, guiders, and breaker plates.	Maintain dies, guiders, breaker plates, and approach so they are clean, highly polished, and free from rust, pits, burs, and any buildup.		
			Improper startup and shutdown procedures.	Standardize startup, shutdown, and cleanout procedures to provide: 1) Adequate bleeding before beginning new run. 2) Continuous bleeding at low RPM with screw cooling turned off and barrel heats decreased during temporary shutdowns. 3) Sufficient flushing of barrel with head open before shutting down for extended periods. 4) Proper cleanup of tools while still warm. Tools and dies should never be burned out to clean.		

Symptom	Basic Defect	Constructions Normally Exhibiting Defect	Cause of Problem	Immediate Corrective Action Preferred	Immediate Corrective Action Alternative	Major Improvements Needed
D. Large blisters or bubbles in insulation.	Volatiles carried into the crosshead by marker thread or conductor which are trapped by the extruded PVC and expand upon leaving the die to give blisters.	Construction using stranded conductors and/or marker threads.	Moist or oily conductor.	Clean, wipe, and preheat the conductor. See IA.		
			Conductor with a loose strand.	Check stranding of wire to be sure it is tight and uniform.		Improve and clean up stranding operation.
			Wet marker thread.	Preheat marker thread in oven or dry by passing it over heat lamp while running.		
III. SURFACE DEFECTS						
A. Fine pimples similar to grains of sand sprinkled over surface.	Uncolloided resin particles due to inadequate shearing by the screw or inherent hard gels.	Any construction; in particular, those with heavy walls.	Inadequate screw design for low back-pressure extrusions.	Increase screen pack – more or finer screens.	Decrease line speed.	Replace screw with shallower flight depth metering section screw.
				Decrease space between wire guider and die.		Extend barrel length.
				Use long land dies.		
				Adjust screw cooling.		
				Raise temperature of controlling barrel heat zones.		
B. Coarse grainy surface accompanied by porosity just under the surface.	Moisture in material.	See IIB.	See IIB.	See IIB.		See IIB.
C. Fine grainy surface occurring over entire surface or portions of it at regular intervals.	1) Material sticking to dies as it leaves crosshead.	Any construction.	Cold, pitted, or dirty dies.	Thoroughly clean die. Polish until all depressions are removed.		Replace die and improve procedure for care and cleaning of dies and tools.
	2) Strains due to elastic turbulence at high rates of flow.	Peculiar to high-speed extrusion.	Poor streamlining and abrupt angles in approach to die.	Raise stock temperature by: 1) Adjusting screw cooling. 2) Raising temperature of barrel and crosshead. 3) Increasing screen pack.	Decrease line speed.	Lengthen approach to die. Eliminate abrupt angles and streamline die and approach. Increase land length of die.

COMMON PROBLEMS ENCOUNTERED IN THE EXTRUSION OF PVC AND THEIR SOLUTION

Symptom	Basic Defect	Constructions Normally Exhibiting Defect	Cause of Problem	Immediate Corrective Action		Major Improvements Needed
				Preferred	Alternative	
D. Sporadic lumps of large size, usually accompanied by porosity. In severe cases, whole sections break down, leaving craters in the surface.	Degraded stock which has a consistency stiffer (higher melt viscosity) than normal PVC at extrusion temperatures.	See IIC.	See IIC.	See IIC.	Decrease line speed.	See IIC.
E. Sporadic lumps and general bumpy surface (orange peel).	Uneven stock viscosity caused by hot and cold stock or, in extreme cases, fused and partially fused material.	Any construction.	Nonhomogeneous melt delivered to die.	See IIIA.	Decrease line speed.	See IIIA.
F. Sporadic lumps containing different colored or textured materials. High incidence of sparker failures.	Foreign contamination in stock.	Any construction.	Break in screen pack. No guards on hopper. Careless handling of feed stock or of material containers.	Flush out extruder barrel and thoroughly clean head. Avoid storing feed stock in open containers. Take care when emptying bags to keep paper out of hoppers.		Install guards around hopper. Place hardware cloth over hopper opening to the extruder to prevent large objects from entering feed sections of extruder.
G. Raised lines on surface.	Uneven die surface.	Any large constructions, particularly heavy-wall jackets.	Damage to die due to improper handling and care.	Thoroughly clean die. Polish until all depressions are removed.		Replace die and improve procedure for care and cleaning of dies and tools.
H. Grooves in surface.	Degradation buildup on inside of die – lumps of degradation stock too stiff to flow through the die.	See IIC.	See IIC.	See IIC.	Decrease line speed.	See IIC.
I. Dimples in surface.	Uneven distribution of stock flow around complex shape.	See IIC.	See IIIC2. Also guider angle may not correspond to angle of die.	See IIIC2.	Decrease takeoff speed and extruder RPM.	See IIIC2. Gradually change shape of guider and die to final geometry of construction from round shape of approach.
J. Holes or splits in jacket.	Drawdown of material exceeding elastic limit of extruded stock.	Small thin-walled tubed-on jackets.	Die opening too large – out of proportion for construction requiring excessive drawdown.	Raise crosshead and die temperatures. Cut RPM.	Extrude insulation directly on small conductor rather than on tubing.	Replace with die having smaller opening properly proportioned to desired construction dimension.

Symptom	Basic Defect	Constructions Normally Exhibiting Defect	Cause of Problem	Immediate Corrective Action: Preferred	Immediate Corrective Action: Alternative	Major Improvements Needed
IV. RATE						
A. Fluctuation in rate-surging.	Inadequate back-pressure for screw design.	See IIA.	Inadequate screw design for low back-pressure extrusions.	See IIA.	Decrease line speed.	See IIA.
	Uneven feed stock temperatures.	Not related to construction.	Hot feed stock used with no provision to keep temperature constant.	Let feed stock cool to room temperature. Hold feed stock in extruder hopper to constant elevated temperature ±1°C.		
	Bridging in extruder hopper.	Not related to construction.	Poor flow due to poor granulation or foreign contamination. Dry blend with poor flow characteristics. Poorly designed hopper and hopper throat.	Hand feed or carefully watch feeding of material. Use hopper cooling (if available). Avoid contamination.		Install agitator inside hopper or vibrator on hopper. Redesign hopper and/or hopper throat.
	Bridging in feed section of screw.	Not related to construction.		Maintain barrel temperature at hopper between 150°F-200°F. Adjust worm water to insure cool screw surface in feed section.		Polish feed section of screw.
B. Low rate.	Overly high back-pressure for screw design.	Thin-wall insulation on smaller-gauge wires.	High back-pressure die with deep-flighted screw.	Decrease screen pack to minimum, normally 1-40 and 1-60. Increase space between guider and die. Increase temperature of crosshead.		Redesign die and guider to give: 1) Greater difference in angle between guider and die. 2) Better streamline flow. 3) Larger die opening. Replacement of screw with one of proper design.
	Too-low output from screw design.	Not related to construction.	High-pressure screw with slow pitch or relatively shallow final flight depth - a screw designed basically for another thermoplastic.	Limit screw cooling to feed section. Increase barrel heats in front sections.		Replacement of screw with one of proper design.
	Worn extruder.	Not related to construction.	Clearance between screw and barrel too great, e.g., .040" as an extreme case. Surface of barrel smoother than surface of screw.	Polish surface of screw. Roughen surface of barrel.		Replace barrel or barrel liner. Replace screw. Replace extruder.