

## RECYCLING DESIGN GUIDE

## GM502M

**1 SCOPE.** This document was created to aid the GM design community in designing more recyclable vehicles, that have maximum end of life value. The tools included will help the design engineer analyze parts and assemblies for recyclability. This is accomplished through the use of a Recyclability Checklist, general design for recyclability guidelines, specific material guidelines, and a method to calculate percent recyclable. The guide contains the following:

|                                                    |            |
|----------------------------------------------------|------------|
| General Recycling Design Guidelines.....           | Section 3  |
| Material Specific Recycling Design Guidelines..... | Section 4  |
| Plastics.....                                      | 4.1        |
| Metals.....                                        | 4.2        |
| Textiles.....                                      | 4.3        |
| Rubber.....                                        | 4.4        |
| Glass.....                                         | 4.5        |
| Recyclability Checklist Form.....                  | Appendix A |
| Subsystem Checklist Results Form.....              | Appendix B |
| Recycled Content Reporting Form.....               | Appendix C |
| Method to Calculate % Recyclable.....              | Appendix D |
| GM Recycling Definitions and Glossary.....         | Appendix E |
| Statement of Current Recycling Technology ...      | Appendix F |
| Compatibility Chart.....                           | Appendix G |

1.1 Recycling technology is rapidly changing today. This document is written for current recycling technology (for a description of current technology see Appendix F). As technologies develop the Design Guide will be updated.

1.2 KEY WORDS: Design Guide, Plastic, Metal, Textile, Rubber, Glass

## 2 REFERENCED STANDARDS.

|         |            |         |
|---------|------------|---------|
| GM1000M | 9985725    | VDA-260 |
| GM1738M | SAE J1344  |         |
| GM7400M | ISO 1043-1 |         |

## 3 GENERAL RECYCLING DESIGN GUIDELINES.

### 3.1 MATERIAL SELECTION.

3.1.1 Standardize Material Selection. Standardize material types(s) used on specific components or subsystems across product lines. Refer to NAO Preferred Materials Catalog.

#### 3.1.2 Select Recyclable Materials.

3.1.2.1 Select plastic, textile, and rubber materials for which recycling technologies are currently practiced.

3.1.2.2 Consider recycling technologies that preserve the greatest material value.

3.1.2.3 All metals are considered recyclable.

3.1.2.4 Glass is recyclable when it is not laminated, coated or bonded to metal or plastic components.

3.1.3 Use Recycled Materials. Select materials that have Post Consumer or Post Industrial recycled content. Consider validating equivalent virgin material as a back-up.

3.1.4 Reduce or Eliminate Coatings. Uncoated materials are easier and less costly to recycle than coated materials.

3.1.5 Limit Material Types Used Within Assemblies. Minimizing the number and types of materials in an assembly minimizes end-of-life-cycle separation and recycling costs.

3.1.6 Use Compatible Materials In Assemblies. When the use of only one polymer or metal in an assembly is not possible, select materials that are compatible for recycling without complete disassembly.

3.1.7 Use Compatible Materials In Laminates/Composites. Select metals, plastics, textiles and adhesives that do not require separation for recycling.

3.1.8 Use Materials With Greater Than 0.03 Density Differences. If incompatible materials are used in an assembly, choose materials with greater than 0.02 density differences to facilitate separation.

3.1.9 Restricted and Reportable Chemicals (GM1000M). All materials supplied to this specification must comply with the requirements listed in GM1000M, "Restricted and Reportable Chemicals".

### 3.2 DESIGN FOR DISASSEMBLY AND RECYCLING.

3.2.1 Integrate Parts. Minimize the number of parts within an assembly. Utilize Design for Manufacturability/Design for Assembly (DFM/dfa) techniques to optimize integration.

#### 3.2.2 Fastening/Attachment.

3.2.2.1 Minimize the number and type of fasteners used in an assembly. Refer to the NAO Fasteners Catalog.

3.2.2.2 Design assemblies so they may be easily removed from a vehicle for reuse or recycling.

3.2.2.3 Utilize mechanical attachments which allows for easy separation of components within an assembly.

3.2.2.4 Use molded-in snap fits on plastic parts, where possible, instead of metal clips.

3.2.2.5 Minimize the attachment of dissimilar materials. If dissimilar materials must be joined, do it in a way that they can easily be separated. Do not weld dissimilar materials. Avoid steel fasteners in aluminum parts. Avoid copper brazing of ferrous parts.

3.2.2.6 Minimize the use of adhesives. If adhesive bonding is required, utilize adhesives and substrates that are compatible together for recycling.

## RECYCLING DESIGN GUIDE

### GM502M

#### 3.2.3 Maximize Use Of Black Components.

3.2.3.1 Design and select plastic and textile materials and trim assemblies that use black or heather colored materials to enhance the use of recycled materials.

3.2.3.2 For black plastic nonappearance or covered/coated parts, specify 25% minimum recycled content.

3.2.4 Marking Of Plastic And Rubber Parts. Use SAE J1344 to mark all plastic parts that are large enough to mark. Rubber parts should be marked using designations shown in Appendix F of SAE J1344. For size and location reference GM7400M.

3.2.5 Marking Of Aluminum And Magnesium Parts. Aluminum and magnesium parts should be labeled with the alloy.

3.2.6 Recyclability Checklist. Use Appendix A of this document to identify opportunities to maximize the recyclability of a design concept. Use Appendix B to document decisions.

3.2.7 Percent Recyclable Content. Utilize Appendix D of this Document to calculate the recyclable content (% by weight) of a design concept.

3.2.8 Reporting Recycled Content. Use Appendix C of this document to report recycled content. Questions related to completing this form should be directed to the Material Engineering Department of the procuring GM Division.

3.2.9 Glossary Of Recycling Terms. Refer to Appendix E of this document for GM recycling definitions.

#### 3.3 PACKAGING.

3.3.1 Minimize Packaging And Packaging Offal. Select packaging for parts and materials that is reusable, has recycled content and/or is recyclable. Where possible design parts/assemblies that minimize packaging needs. Reference GM Packaging Specification, GM1738M.

3.3.1.1 Eliminate wherever possible the use of plugs, caps, and covers. Some of the plugs, covers, and caps were originally intended to protect parts during shipment in bulk loaded containers. The assemblies may now be shipped in layered trays, to protect them; but the plug, cover, and cap has not been eliminated.

3.3.1.2 Use a common material for all necessary plugs, caps, and covers. Low density polyethylene (LDPE) and polyethylene terephthalate (PET) are preferred materials because of the current recycling market.

3.3.1.3 Use a natural color resin if possible for all plugs, caps, and covers. Natural resin is easier to sell in the recycled market than colored resin.

3.3.1.4 Mark all plastic plugs, covers, and caps. Identify the type of plastic by marking each part with the appropriate SPI symbol for packaging materials.

## 4 MATERIAL SPECIFIC RECYCLING DESIGN GUIDELINES.

### 4.1 PLASTICS.

4.1.1 Thermoset materials can be ground and put back in as a filler or in some cases replace resin in a small percentage.

4.1.2 Thermoplastic materials can be remelted and used up to 100% in similar or less demanding applications.

4.1.3 Avoid color matching of substrates for painted parts. If painting is necessary, use one color for plastic substrate. This makes it easier to reuse unpainted scrap in the process and reduces scrap generated from color changes during the molding process.

4.1.4 Typical examples of post consumer recycled content.

4.1.4.1 Recycled polyester soda bottles are used in exterior door escutcheons, modular headlines, nonwoven sound absorbers, dielectric pads, trim pads, and trunk trim.

4.1.4.2 Recycled polycarbonate from compact discs and water bottles is used for headliner hardware.

4.1.5 Typical examples of post industrial recycled content.

4.1.5.1 TPO fascia plant scraps going into Saturn wheel well liners.

4.1.5.2 Recycled plant scrap SMC going into Corvette inner panels.

### 4.2 METALS.

4.2.1 Low-alloy metals are more recyclable than high-alloy metals.

4.2.2 Unplated metals are more recyclable than plated ones, such as galvanized steel.

4.2.3 Metal matrix composites which contained a durable preform probably will be more recyclable than those which contain distributed particles or fibers.

4.2.4 Steel bar and wire products have a higher recycled content than steel products. Steel bar and wire are usually produced in electric arc furnaces which use 99% recycled materials. Steel sheet is produced in basic oxygen furnaces which use only 25 to 30% recycled content.

4.2.5 Aluminum and magnesium die casting alloys generally have higher recycled content than do wrought alloys.

4.2.6 Special high grade (SHG) zinc made from recycled castings is pure enough to be used in making new casting alloys.

4.2.7 Lead, mercury, cadmium, arsenic, and zinc coatings may cause recycling or disposal problems.

## RECYCLING DESIGN GUIDE

### GM502M

4.2.8 Contamination of a metal with another metal reduces recyclability. Contamination may take the form of fasteners, inserts, bearings, platings, coatings, or other components which are not separated by the dismantling, shredding and sorting process.

4.2.8.1 Contamination of iron or steel with copper, tin, zinc, lead, or aluminum reduces recyclability.

4.2.8.2 Contamination of aluminum with iron, steel, chromium, zinc, copper, or magnesium reduces recyclability.

4.2.8.3 Contamination of zinc with iron, steel, lead, tin, or cadmium reduces recyclability.

4.2.8.4 Contamination of magnesium with other metals reduces or precludes recyclability.

4.2.8.5 Organic or nonmetallic coatings are preferred for use when corrosion resistance is an issue in conjunction with recyclability.

4.2.8.6 For wear resistance surface harden steels rather than plate.

4.2.9 Casting may replace assemblies which use multiple parts. Castings may be used as both structural member and bearing material.

4.2.10 Minimize metal offal. Design parts and specify manufacturing processes to optimize metal usage. Minimize machining. Maximize stamping yield of sheet. Minimize risering of castings.

#### 4.3 TEXTILES.

4.3.1 Flat woven cloths made with longer fibers are of greater recycling value than pile cloths.

4.3.2 Fabric tri/bilaminates are currently recycled into carpet underlayment pads.

4.3.3 Textile materials made from polyester, nylon, and polypropylene are more recyclable than other fibers such as acrylics.

4.3.4 Unsupported vinyls are currently recycled into automotive and nonautomotive applications.

4.3.5 Supported vinyl by itself is not a compatible composite and reduces material recyclability.

4.3.6 Use of low pressure injection molding utilizing compatible materials such as TPO and polypropylene or polypropylene and polypropylene improves the recyclability of both the part and the offal.

4.3.7 Reduction of incompatible back coatings i.e. latex, PSA, and EVA, improves recyclability. Knit cloth offers the potential to eliminate backcoatings.

4.3.8 Minimize trim material offal. Design trim assemblies and cutting tools that optimize textiles material usage.

4.3.8.1 Greater material utilization is more often achieved with numerical cutting over steel rule tools.

4.3.8.2 Revisions to nap direction may improve nesting and overall material usage.

4.3.8.3 Near-net-shape manufacturing reduces offal.

4.3.9 Black PET fiber often has recycled content and could be used in applications such as trunk trim, functional materials and flocking.

4.3.10 Recycled fabric made from nylon, polyester, acrylic, and cotton is used in needled resinated sound absorbers.

4.3.11 Use of polyester fabric with polyester nonwoven dielectric pads improves recyclability and its further enhanced by bonding to a polyester or other compatible substrate.

4.3.12 Elimination of cloth seaming lace for seat applications improves recyclability.

4.3.13 Use of heat fused nonwoven carpets eliminates the need for backcoatings, improves recyclability and makes the offal recyclable.

#### 4.4 RUBBER.

4.4.1 Investigate thermoplastic elastomers (TPE) as an alternate to thermoset rubber. TPE is currently easier to recycle.

4.4.2 Recycling options for thermoset rubber are as follows:

4.4.2.1 Regrind - A percentage of reground rubber can be put into parts that do not have stringent performance requirements.

4.4.2.2 Devulcanization - Dayco/Anchor Swan has two methods of devulcanizing rubber (chemical and microwave). The resulting material can be put into virgin material in limited quantities. (This technology appears to still be in the development stage)

4.4.2.3 Chemical Recycling - Pyrolysis can be used to recover energy through gas and oil. (Not economical at this time)

4.4.2.4 Energy Recycling - Rubber materials have very high fuel value. The industry has had success in using tires in cement kilns, pulp and paper mills, waste to energy plants, etc.

4.4.2.5 Building Applications - Tires have been used to build embankments, underwater reefs, in roofing material, on boat docks, etc. They have been shown to pose no environmental threat in these applications (no leaching).

4.4.3 Use Recycled Content. Automotive grade thermoset rubbers used for weatherstrips, motor mounts, tires, hoses,

## RECYCLING DESIGN GUIDE

### GM502M

belts, seals, and gaskets do not currently contain recycled material.

4.4.3.1 Thermoset rubber parts such as mats and truck bed liners can be made with a percentage of reground rubber material.

4.4.3.2 Automotive grade TPE's could contain reprocessed plant scrap.

#### 4.5 GLASS.

4.5.1 Clean glass is recyclable. Minimizing contaminants makes automotive glass more recyclable. Recycling options for automotive glass are as follows:

4.5.1.1 Clean Cullet (crushed glass scrap) - Plant scrap with no coatings or other contamination is directly recycled back into the float process. Post consumer clean cullet, side glass with no coatings, must be returned to the original supplier to go back into the float process.

4.5.1.2 Painted Cullet - Plant scrap is reused in applications such as fiberglass, glass bead, concrete, etc. Post consumer painted glass, backlights, tinted glass, mirrors, could go into similar applications.

4.5.1.3 Laminated Glass - Windshield plant scrap is sent to a recycler and the plastic is separated from the glass. The glass

is reused in applications similar to those listed for painted cullet. The plastic, which is polyvinyl butyrate, is currently landfilled because of glass contamination. Both the recyclers and the plastic suppliers (DuPont, Monsanto) are looking for possible uses for the plastic. Post consumer windshields could be processed in a similar manner.

4.5.1.4 Encapsulated Glass - The tempered glass can be broken and separated from plastic (RIM or PVC) and go into applications similar to those listed for painted cullet. The plastic can be used back into the same application if it is PVC (being done by Delphi).

4.5.2 Used Recycled Content. The float process, used to make sheet glass, utilize approximately 25% plant scrap. Fiberglass insulation in cars contain painted and/or coated plant scrap.

**5 GENERAL INFORMATION.** This guide was originated in August 1993 and approved in November 1993. The latest revisions include:

| Rev | Date  | Description       |
|-----|-------|-------------------|
| A   | 7/94  | Add Appendix B, D |
| B   | 12/95 | Complete revision |

# **RECYCLING DESIGN GUIDE** **GM502M** **APPENDIX A** **RECYCLABILITY CHECKLIST**

**A1** The purpose of this checklist is to provide a tool for identifying concerns related to the recyclability, including reuse, of body and chassis components or assemblies at the end of the vehicle's useful life. For more information reference the GM Recycling Design Guidelines.

NOTE: The (-) items circled in the checklist have issues associated with them that should be reviewed with the appropriate Materials Engineer(s).

NOTE: The (+) items circled in the checklist are considered recyclable and no review is required.

| QUESTION                                             | CIRCLE RESPONSE                       | REMARKS                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                      | <b>ADD COMMENTS WHERE APPROPRIATE</b> |                                                                                                                                                                                                                                                                                                                                                                    |
| <b>MATERIAL SELECTION</b>                            |                                       |                                                                                                                                                                                                                                                                                                                                                                    |
| 1. What is the part/assembly made from?              |                                       |                                                                                                                                                                                                                                                                                                                                                                    |
| - METAL                                              | (+)                                   | Metals from retired vehicles are currently recycled.                                                                                                                                                                                                                                                                                                               |
| - PLASTICS                                           | (+)                                   | There are technologies to recycle all plastic materials if they can be separated into relatively pure streams.                                                                                                                                                                                                                                                     |
| - GLASS                                              | (+)                                   | Clean glass is easily recycled.                                                                                                                                                                                                                                                                                                                                    |
| - RUBBER                                             | (+)                                   | There are technologies to recycle all rubber materials if they can be separated into relatively pure streams.                                                                                                                                                                                                                                                      |
| - TEXTILES                                           |                                       | Textiles include leather, carpet, body cloth, vinyl, etc..                                                                                                                                                                                                                                                                                                         |
| If compatible in subassembly                         | (+)                                   |                                                                                                                                                                                                                                                                                                                                                                    |
| If incompatible in subassembly                       | (-)                                   |                                                                                                                                                                                                                                                                                                                                                                    |
| - LAMINATES/COMPOSITES                               |                                       | Difficult to separate for recycling. As a general rule, mixtures of dissimilar plastics should be considered as incompatible. Consequently, the recyclability of mixed plastics can be severely restricted if they are incompatible. It is advised that a materials engineer, knowledgeable in plastics, be consulted when choosing plastics for component design. |
| If compatible materials                              | (+)                                   |                                                                                                                                                                                                                                                                                                                                                                    |
| If incompatible materials                            | (-)                                   |                                                                                                                                                                                                                                                                                                                                                                    |
| - FOAM                                               |                                       | Urethane foam processing scrap is currently recycled into carpet backing. Difficult to separate for recycling.                                                                                                                                                                                                                                                     |
| If same as material bonded to                        | (+)                                   |                                                                                                                                                                                                                                                                                                                                                                    |
| If different than material bonded to                 | (-)                                   |                                                                                                                                                                                                                                                                                                                                                                    |
| - WOOD PRODUCTS                                      | (-)                                   | Generally bonded to textiles which makes them not recyclable. (Alone they are recyclable).                                                                                                                                                                                                                                                                         |
| 2. Does the part/assembly contain recycled material? |                                       | Specifying recycled materials helps to create the market for them.                                                                                                                                                                                                                                                                                                 |
| If YES, circle                                       | (+)                                   |                                                                                                                                                                                                                                                                                                                                                                    |
| If NO, circle                                        | (-)                                   |                                                                                                                                                                                                                                                                                                                                                                    |

**RECYCLING DESIGN GUIDE**  
**GM502M**  
**APPENDIX A**  
**RECYCLABILITY CHECKLIST**

|                                                                                                                     |                |                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3. Has material choice been compared to same application in other vehicle lines.<br>If YES, circle<br>If NO, circle | <br>(+)<br>(-) | Consider standardized material types for selected applications across product lines.                                                                                         |
| 4. Are the part/assembly and/or fasteners made from different materials?                                            | (-)            | Having to try to separate dissimilar materials hinders recycling.                                                                                                            |
| 5. Is the part/assembly coated?                                                                                     | (-)            | Includes paint, film, foils, plating, laminating.                                                                                                                            |
| 6. Is the supplier aware of Material Selection Guidelines and implementing them?<br>If YES, circle<br>If NO, circle | <br>(+)<br>(-) | Reference GM1000M, Restricted and Reportable Chemicals.                                                                                                                      |
| <b>FASTENERS</b>                                                                                                    |                |                                                                                                                                                                              |
| 1. If an assembly, how are components attached?                                                                     |                |                                                                                                                                                                              |
| - SNAP FITS                                                                                                         | (+) (-)        |                                                                                                                                                                              |
| - ADHESIVES<br>If compatible in subassembly<br>If incompatible in subassembly                                       | <br>(+)<br>(-) |                                                                                                                                                                              |
| - THREADED SCREWS and/or RIVETS<br>If compatible in subassembly<br>If incompatible in subassembly                   | <br>(+)<br>(-) |                                                                                                                                                                              |
| - WELDING<br>Similar materials<br>Dissimilar materials                                                              | <br>(+)<br>(-) | Welding includes: vibration, sonic, solvent, hot plate, and spin welding.                                                                                                    |
| <b>DESIGN/MANUFACTURING</b>                                                                                         |                |                                                                                                                                                                              |
| 1. Are the parts or all components of assembly marked for plastic type?<br>If YES, circle<br>If NO, circle          | <br>(+)<br>(-) | SAE J1344 is the industry standard for marking plastic parts. It can also be used for TPE's. A system is being developed for rubber. Glass is currently marked.              |
| 2. Have DFM and DFD been considered?<br>If YES, circle<br>If NO, circle                                             | <br>(+)<br>(-) | Using DFM to integrate parts will help eliminate fasteners and reduce material types. DFD (design for disassembly) will make the part easier to remove and reuse or recycle. |