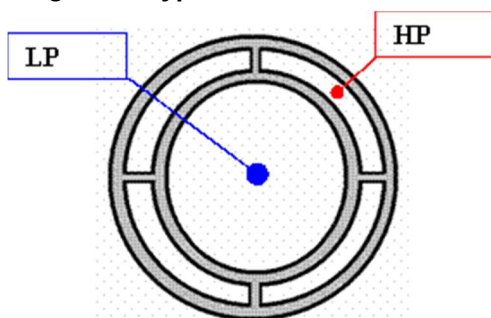


The maximal liquid volume for R1234yf refrigerant shall not exceed 35.5 cm³ for 500 mm center line length of the liquid line as defined for IHX Type I (end blocks included) in Appendix A and for IHX Type II (IHX included) in Appendix B. No requirement is defined for an IHX for R-134a refrigerant.

3.1.2.1.2 Type I: Coaxial Tube IHX. A coaxial tube IHX consists of the inner tube (suction line) and the outer tube, which contains the liquid refrigerant. Figure 1 shows the cross section of a typical coaxial tube IHX manufactured by an extrusion process.

Figure 1: Typical Coaxial IHX Profile

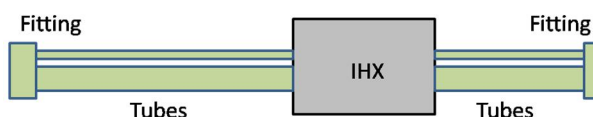


3.1.2.1.2.1 Cross Section Deformation. The maximum allowed reduction of the cross section area by deformation (e.g., bending) shall not exceed 20 % of the original area at minimum bend radius.

3.1.2.1.2.2 Transitional End Blocks. The shape and size of the end blocks (feature used to separate coaxial configuration into separate liquid and suction pipes) is generally the supplier's design and shall be agreed to by the BFO.

3.1.2.1.3 Type II: Non-Coaxial Tube IHX. The design of a non-coaxial tube IHX shall allow the integration of the IHX in the vehicle body line without adding additional fittings or adding an additional amount of refrigerant (see paragraph 3.1.2.1.1) compared with a coaxial IHX. Figure 2 conceptually represents a non-coaxial tube IHX design.

Figure 2: Type II IHX integrated in Body Line



3.1.2.2 Functional Content. The functional characteristics of the internal heat exchanger, such as the effectiveness, the performance versus mass flow and the pressure drop, shall be optimized, validated and released for specific GM applications.

3.1.2.2.1 The design of the IHX shall prevent an accumulation of compressor lubricant to assure a good lubricant circulation within the A/C system. See GMW16241 for further details.

3.1.3 Ambient Environment. The internal heat exchanger shall be capable of withstanding ambient temperature variations from (-40 to +150) °C ((-40 to +250) °F), (0 to 100) % relative humidity, and exposure to a severe corrosive environment.

3.1.4 Interfaces. If the IHX is not integrated in the A/C body line as part of the assembly, the IHX joints shall utilize mini-block fittings and seal washers to connect the IHX with the liquid line and the suction line.

3.1.4.1 All joints and seals shall comply with GMW15779 and GMW15787 – no deviations will be permitted.

3.1.4.2 Soldered braze connections shall comply with GMW14655.

3.1.5 Usage Definition. Internal heat exchangers as body line part of assembly (POA), or as a single component for R134a or R1234yf refrigerant systems described by this specification, are used in passenger and light commercial vehicles.

3.1.5.1 Noise and Vibration. The IHX shall not transmit nor generate any squeak and rattle, mechanical or acoustical Noise, Vibration, Harshness (NVH) signatures that are perceptible to the vehicle occupants. This includes, but is not limited to:

- IHX natural frequencies and resonances that are sympathetic to engine firing frequency or compressor frequency.
- Vibrations and resonance that are conducted through the steering wheel, floor pan or seats.
- Acoustic whistle/whine/gurgle/hiss sounds created by refrigerant flow that are observable at a distance of 1 m from the IHX test sample.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Test Conditions. All measuring variables as specified in this document shall be determined correctly with respect to its physical definition.

3.2.1.1.1 If not otherwise required by the appropriate test paragraph, all tests shall be performed at room temperature (RT): $RT \triangleq (+23 \pm 5) ^\circ C$.

3.2.1.1.2 A storage time of 24 h minimum is required after production of the test sample prior to running the first test. Between the tests, the samples shall be stored at RT with protective caps at each end, but without any kind of refrigerant charge.

3.2.1.2 Supplier Qualification.

3.2.1.2.1 IHX Type I (Coaxial Tube Type). The intent of this performance evaluation is to demonstrate that the supplier's coaxial tube heat exchanger profile design fulfills the thermodynamic requirements for pressure drop, heat exchange and effectiveness. Therefore, the IHX shall be tested in a test setup which represents a typical vehicle body line (see Appendix A). The supplier's IHX cross section design shall meet all of the qualification requirements and shall be approved by the General Motors IHX BFO prior to the supplier being permitted to bid on IHX business.

3.2.1.2.2 IHX Type II (Non-Coaxial Type). The intent of this performance evaluation is to demonstrate that the supplier's IHX design fulfills the thermodynamic requirements for pressure drop, heat exchange and effectiveness. Therefore, the IHX shall be tested in a test setup which represents a typical vehicle body line (see Appendix B). The supplier's IHX design shall meet all of the qualification requirements and shall be approved by the General Motors IHX BFO prior to the supplier being permitted to bid on IHX business.

Table 1: Supplier Qualification Tests

Paragraph	Test	Number of Samples
4.3.1	Heat Transfer	1
4.3.2	Pressure Drop	1 (same as paragraph 4.3.1)
4.3.3	Effectiveness	1 (same as paragraph 4.3.2)

3.2.1.2.3 Test Samples. The performance validation tests shall be performed with a test sample according to Appendix A for a Type I IHX (coaxial tube) or Appendix B for a Type II IHX (non-coaxial tube design). The tests given in Table 1 shall all be performed with the same test sample. All coaxial IHX designs shall be formed in the U-tube shape shown in Appendix A, Figure A1.

Other IHX designs, like plate type, shall have the test sample size and shape shown in Appendix B, Figure B1. All test samples shall be approved by the BFO prior to the tests. When the tests are successfully finished the tested samples shall be handed over to the BFO.

The test conditions are the same regardless of the IHX technology.

The materials and material suppliers used for the qualification samples shall be kept for the production parts. A change of the material and/or of the material supplier shall be agreed by the GM Release Engineer.

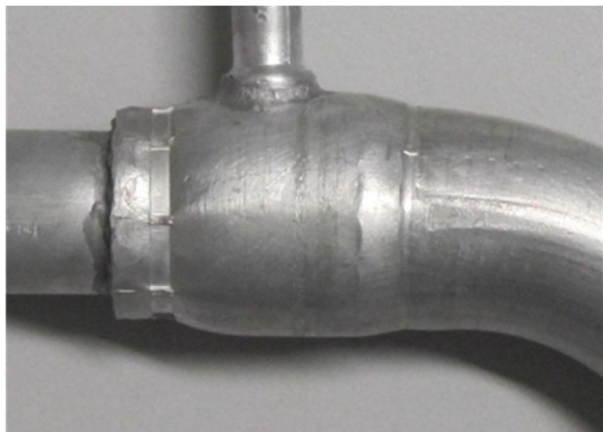
3.2.1.2.4 End Blocks. The end blocks (see Figure 3) which join and split the suction line and the liquid line before and after the IHX (valid only for coaxial Type I) are part of the IHX evaluation. The design of these blocks shall therefore be production intent and agreed by the responsible BFO.

If the end blocks are no separate parts but integrated in the IHX they shall fulfill the following requirements:

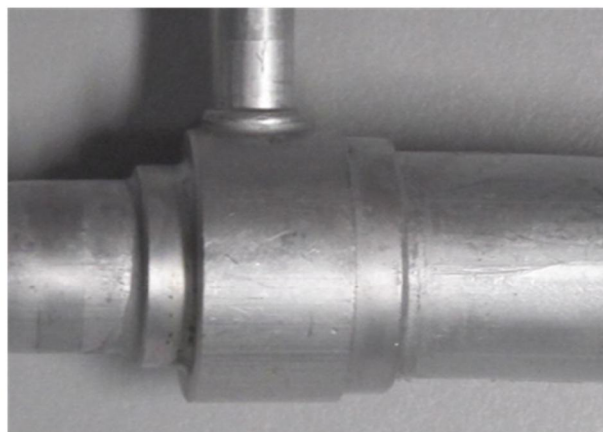
- The wall thickness of the forming areas shall be $\geq 80\%$ of the original wall thickness of the IHX.
- No orange peel or micro cracks in the forming areas.

- The minimum radiuses shall not underrun 1.5 mm

Figure 3: Samples of Integrated and Separate End Blocks



A



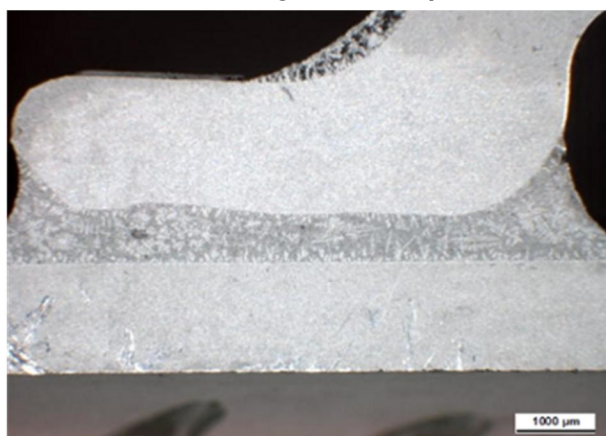
B

A End block (splitter) as integrated part of the IHX

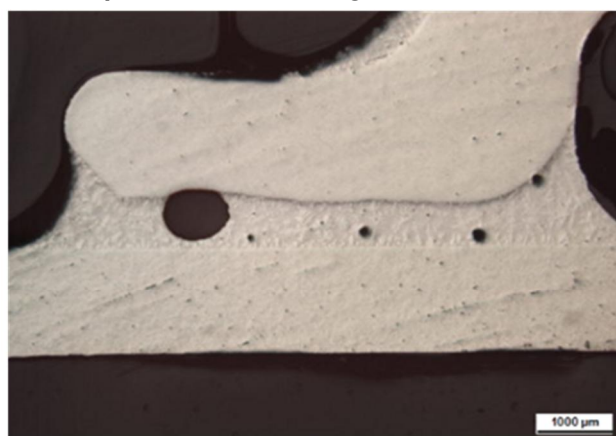
B Separate end block

For all types of end blocks the supplier shall provide polished cut images of the end blocks for further investigation by the ITDC laboratory (see Figure 4). A detailed description of how the cut images shall be prepared can be found in Appendix D.

Figure 4: Samples of Good and Bad Preparation of Cut Images



A



B

A Bad preparation, all brazing errors are filled with Aluminum particles produced during the preparation

B Good preparation, same cut, all the brazing errors are visible

3.2.1.2.5 Performance Requirements. The performance requirements for Heat Transfer, Pressure Drop and Effectiveness are given in Table 4, Table 5 and Table 6.

3.2.1.3 Deviations from this Standard. Deviations from the requirements of this standard shall have prior written approval from the responsible GM IHX BFO. Such deviations shall be specified on component drawings, test certificates, reports, etc.

3.2.2 Physical Characteristics. See paragraph 3.3.2.1.

3.2.2.1 Dimensions and Capacity. See paragraph 3.3.2.1.

3.2.2.2 Mass Properties. Not applicable.

3.2.3 Reliability. Not applicable.

3.2.4 Serviceability. Not applicable.

3.2.5 User System/Subsystem/Component/Part Interface. Not applicable.

3.3 Design and Construction.

3.3.1 Materials, Processes and Parts Selection Guidelines. See paragraph 3.3.2.1.

3.3.1.1 Material Guidelines.

3.3.1.1.1 Recycling Guidelines. Materials developed to this standard shall be optimized to provide maximum end-of-life cycle value utilizing the Recyclability Checklist and GM Recycling Design Guidelines. Recycled content shall be reported to the approving and procuring Materials Engineering department utilizing the Recycled Content Report Form. Reference the Recyclability/Recoverability Guidelines to GMW3116.

3.3.1.1.2 Material Compatibility. All materials which are used for outer surfaces of the IHX shall withstand all environmental influences normal for an engine compartment (e.g., engine oil, fuel, brake fluid) without deterioration.

The data sheet of these materials will be accepted as certificate (proof of compliance).

3.3.1.1.2.1 The inner surfaces of the IHX shall withstand the components of the refrigerant and the lubricants given by R134a (GMW5038), R1234yf (GMW16283), Polyalkylene Glycol (PAG) Oil (9985752) and Polyolester (POE) Oil.

3.3.1.2 Processes Guidelines. All production internal heat exchangers shall be manufactured using the same materials and processes used to manufacture the originally approved samples. No change is permissible without prior written approval from the responsible GM Release Engineer.

3.3.1.3 Parts Guidelines. Not applicable.

3.3.2 Design Guidelines and Constraints.

3.3.2.1 Drawing Requirements. Internal heat exchangers shall meet the design specifications on the detail drawings approved by GM.

3.3.3 Identification and Marking. Not applicable.

3.3.4 Workmanship. Not applicable.

3.3.5 Interchangeability. Not applicable.

3.4 Documentation.

3.4.1 Failure Mode and Effects Analysis (FMEA). Detailed design and process FMEAs shall be submitted to the GM Release Engineer and GM Validation Engineer, and they will be maintained as part of the records of the Design and Product Validation. The FMEAs shall be updated each time a change occurs. FMEAs shall be submitted with the GM Production Part Approval Process (PPAP) documentation.

3.4.2 Product Validation. The Product Validation requirements for the IHX are described in GMW15773 and/or GMW14319. Documentation shall be through the normal PPAP.

3.4.3 Revalidation Requirements. Any change in design, material, or processing from that previously approved for production requires prior approval and revalidation as determined by the applicable GM Validation Engineer. Carryover designs may be revalidated for subsequent model year production using the results of tests from previous month's production.

3.5 Support of System/Subsystem/Component/Part After Sale. Not applicable.

3.6 System/Subsystem/Component/Part Operator Training. Not applicable.

3.7 System/Subsystem/Component/Part Characteristics. Not applicable.

4 Validation

4.1 General. The tests described in this section are only applicable for IHX supplier qualification. Design Validation (DV) and Product Validation (PV) of IHX assemblies as part of a complete A/C body line are covered by GMW15773 and/or GMW14319.

4.1.1 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the potential safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Note: This standard refers to the usage of testing pressurized vessels, and due to the high pressures inherent with fluorocarbons, testing shall be performed only by properly trained qualified personnel in using equipment capable of withstanding the pressures, temperatures and exposure of these tests with adequate safety margins. Standard laboratory safety precautions shall be followed to prevent accidental bodily injury. All material should be used in accordance with the supplier Material Safety Data Sheet (MSDS).

4.1.2 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

4.1.3 Alternatives. Alternative test facilities and equipment may also be used with prior approval by the General Motors IHX BFO. However, all measuring variables as specified in this standard shall be determined.

4.1.4 Performance without Failure. Performance is defined as successful operation in accordance with the requirements given in paragraph 3.2 and paragraph 4.3. Failure shall be defined as a mechanical, consumer detectable, verified loss of function/performance of one or more components/interfaces resulting in a repair or replacement to restore function to consumer satisfaction.

4.2 Validation Cross Reference Index. See Appendix E.

4.3 Supporting Paragraphs.

4.3.1 Heat Transfer Test. The IHX transfers heat from the high pressure (HP) line to the low pressure (LP) line of the A/C loop to increase the evaporator performance and/or reduce the compressor load.

4.3.1.1 Procedure: Install the IHX reference test sample according to Appendix A (Type I IHX) or Appendix B (Type II IHX) on an appropriate A/C system test bench approved by the BFO. Insulate the IHX to reduce heat transfer losses to the environment.

4.3.1.1.1 Set the operating conditions per Table 2 or Table 3 depending on the refrigerant.

4.3.1.1.2 The test conditions shall be steady-state for ≥ 10 minutes. The corresponding test data shall be recorded.

Table 2: Test Conditions for R134a

Test Data	Unit	Idle	High Load	High Load II
Refrigerant pressure at HP inlet	kPa (abs.)	1600 $\pm$ 30	1300 $\pm$ 30	1600 $\pm$ 30
Refrigerant Temperature HP inlet	°C	+50 $\pm$ 0.5	+45 $\pm$ 0.5	+50 $\pm$ 0.5
Refrigerant pressure at LP inlet	kPa (abs.)	350 $\pm$ 10	300 $\pm$ 10	300 $\pm$ 10
Refrigerant Temperature LP inlet	°C	+15 $\pm$ 0.5	+11 $\pm$ 0.5	+11 $\pm$ 0.5
Refrigerant mass flow	kg/h	100 $\pm$ 2	162 $\pm$ 3	234 $\pm$ 4
Oil Circulation Rate	%	< 1.5		
Deviation of enthalpy differences between HP and LP side of IHX	%	< 3		
Difference of calculated airside and refrigerant side evaporator capacity	%	< 3		