Pressurized Air Hose Band Clamp Connection Joints

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This standard defines the pressurized air hose connection joint utilized with band clamps.

1.2 Applicability. Boosted (i.e., typically turbo charged) air hose connections, which include elastomer hose, band clamp, and a beaded spigot end-form (see Appendix A, Figure A1). The spigot end-form maybe metallic (e.g., machined aluminum, or formed tubing), or composite material.

Typical range of hose Inner Diameter (ID) for pressurized air plumbing is 40 mm to 90 mm, with potential exposure pressures from 80 kPa (absolute) (i.e., slight vacuum) to approximately 300 kPa (absolute), and temperatures of -40 °C to 225 °C.

Applicable to both diesel and gasoline internal combustion engines, utilizing elastomer hose for pressurized air plumbing. Pressurized air elastomer hose connection joints are typical of air communication plumbing, connecting subassemblies, between a turbocharger or similar device and the throttle body or intake manifold.

These elastomer hose connections are typical in the joining and communicating of pressurized air between turbo charger, resonator, Indirect Charge Air Cooler (iCAC), Exhaust Gas Recirculation (EGR) mixers, rigid ducts, throttle body adapter, and throttle body assemblies.

Elastomer hose and connections are typically not utilized post throttle body, where the hose and connections would be exposed to negative pressure (i.e., vacuum).

CG6079 is considered the standard or typical temperature cycles, temperature profiles, and pressure pulsation inputs, the applicable project DRE may indicate different test input values through the SOR Appendix C1 or by continued project learnings.

1.3 Remarks. Elastomer hose may come in various lengths and geometries, ranging from expanded ends to various bend configurations. This specification addresses only the hose end related to the spigot and band clamp joint interface.

Pressurized air elastomer hose joints are typically an enabler for accommodation of manufacturing and assembly build tolerance variation between major subassemblies.

Any photographs taken to record test setup, part failures, or other required objectives, shall be of clear digital quality, so that images may be later reviewed in fine details, through provided test and/or project reports.

Note: For the purpose of this specification, the term band clamp may apply to both worm drive style band clamps and crimped style band clamps. This specification is not applicable to quick connect style connection joints.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM D380	SAE J1508

2.2 GM Standards/Specifications.

9985406	GMW3161	GMW14872	GMW16411
9985770	GMW14234	GMW15272	GMW17245
GMW3044	GMW14671	GMW15408	GMW18047
GMW3059	GMW14726	GMW16177	

2.3 Additional References.

- CG6079 Air Delivery Subsystem - Pressure Pulsation and Temperature Profiles
- Component Technical Specifications (CTS)
- GM Math and Drawing XX079298
- GM Part Number 13433064
- GM Template Drawing XL111429
- SAE-AISI 1008/1010 Steel
- Statement of Requirements (SOR) Appendix C

3 Requirements

3.1 System/Subsystem/Component/Part Definition.

3.1.1 Appearance. Elastomer hoses shall be black in color, unless otherwise specified per unique project requirements.

Clamps shall be typically silver in color, per the given stainless-steel material requirements (see 3.3.1.1).

Spigots color shall be driven by the parent component material or color requirements.

Appearance after corrosion exposure shall be per GMW15272 requirements. Surrogate corrosion data acceptable, only per applicable Design Release Engineer (DRE) agreement.

3.1.2 Content.

3.1.2.1 Physical Content. The joint subsystem facilitates both pressurized air communication and sealing function, shall consist of the following engineered components and/or features:

- Spigot End Form (see Appendix A, Figure A2).
  a. End lead-in and retention bead.
  b. Hose Stop.
  c. Riblets (except formed thin wall tubing and throttle bodies).
  d. Anti-collapse ring (required for all composite spigots).
- Elastomer hose, typically multi-layered, consisting of various elastomer materials and knitted/woven cording.
- Band clamp, which may be worm drive, or crimp style. T-Bolt/coil sprung clamps only acceptable for heavy duty applications, per DRE direction and agreement.

3.1.2.2 Functional Content. The functional content is defined by the standard engineering design features as outlined throughout this document, and the supplier shall aid in ensuring these features best facilitate sealing and joint retention over time.

3.1.3 Ambient Environment. The typical operate environmental exposure ranges are as follows:

- Internal Pressure: 80 kPa to 300 kPa (absolute) (may be up to 400 kPa (absolute) for high performance applications).

Note 1: Pressure exposure is typically full range pulsation over time at given temperatures.

- Internal Temperature: -40 °C to 210 °C.

- External Temperature: -40 °C to 225 °C.
- Humidity: 0% to 100%.
- Interior Constituents: Assembly lubricants, Positive Crankcase Ventilation (PCV) gasses and EGR gasses (acidic level up to 2pH).
- Constituents, exterior: Salts, waxes, and chemical cleaners.

Elastomer hoses shall not be utilized in high negative pressure portion of subsystem (e.g., throttled manifold), which may range from 80 kPa (absolute) down to approximately 20 kPa (absolute).

3.1.4 Interfaces. Pressurized air elastomer hose with band clamp shall be utilized to join subsystem air communication components with spigot end-form as defined by this document.

3.1.5 Usage Definition. Pressurized air elastomer hose band clamp connection joints are typical of boosted (i.e., turbo charged) systems, in which plumbing connections that may facilitate manufacturing build tolerance variation and ergo effort assembly install effort between assemblies may need to be accommodated.

3.2 Product Characteristics. The elastomer hose band clamp joint as defined throughout this document, is meant to maintain joint connection and sealing relative to thermal, vibration, and pressurized air loading over time, and not meant to carry/support additional mass load as a joining component support mechanism (i.e., not carry the mass load of joining components).

3.2.1 Performance Requirements. The pressurized air elastomer hose band clamp joints shall with stand all exposure conditions, and typical under hood fluids exposure, without significant leakage or catastrophic failures. Examples of catastrophic failure may range from band clamp breakage to hose rupture, while leakage conditions may range from improper joint geometries to loss in band clamp load over time.

The elastomer hose band clamp joint shall not separate after a minimum of 300 000 pressure pulsation cycles of 80 kPa (absolute) to application specific (see CG6079 and Statement of Requirements (SOR) Appendix C.1) maximum boost pressure +50 kPa (absolute), unless otherwise specified or agreed upon by the project DRE. This may typically be considered as 80 kPa (absolute) to 300 kPa (absolute) but shall be confirmed per each unique project basis.

It is known that pressure pulsation over time at given temperatures may cause the hose to creep from original installed position towards the spigot end-form bead portion of the bead, however the joint shall be engineered and designed to best resist creepage over time, which may cause impingement of the hose between the clamp and bead. Impingement of the hose between the clamp and bead may lead to eventual or premature failures such as, band clamp coning, hose tearing/damage, or joint separation (i.e., hose blow-off).

It is known that constituents, such as assembly lubricants and PCV condensate (i.e., containing engine oil), may enter the joint potentially contributing to excessive hose slippage or blow-off, and shall be accounted for during the validation testing as outline in Section 4.

3.2.2 Physical Characteristics. The band clamp and spigot bead work in conjunction to accommodate both ergo effort installation and avoiding joint separation (i.e., blow-off) over time. The spigot end-form seal land region riblets feature shall aid in slowing the progression of creepage over time, while the seal land area itself provide sealing surface interface to the elastomer hose (see Appendix A, Figure A5).

3.2.2.1 Dimensions and Capacity. Pressurized air hose ID typically ranges from 40 mm to 90 mm, and the hose nominal ID shall be 0.5 mm to 1.0 mm interface to the spigot Outer Diameter (OD) (specifically the outer surface of riblets, see Appendix A, Figure A5). The joint design shall comprise of the following standard design features:

- Spigot end-form (see Appendix A, Figure A5):
  a. Overall spigot length.
  b. Entry bead conical angle and bead length.
  c. Hose sealing land geometry (e.g., riblets) and minimal length.
  d. Hose stop geometry and alignment feature shape and minimal size.
  e. Anti-crush ring width relationship to spigot (composite spigots only).
- Elastomer hose end requirements (see Appendix A, Figure A6):
  a. Hose end thickness.

b. Hose end perpendicularity maximum allowable tolerance.
c. Hose end minimal straight, outboard of the spigot end.
d. Optional pad mold for clamp retention and positioning.

3.2.2.2 Mass Properties. Not applicable.

3.2.3 Reliability. Reliability is proven through successfully passing the Air Delivery system validation testing as specified per the application SOR Appendix C/Component Technical Specifications (CTS).

3.2.3.1 Reliability Evaluation Point. Successful passing of both Design Validation (DV) and Process Validation (PV) validation testing.

3.2.3.2 Reliability Requirements. End of Test (EOT) criteria per the application specific validation test requirements.

3.2.4 Serviceability. Elastomer hose joints with worm drive style band clamps shall be serviceable, which includes the replace of the hose (and clamps, when Part of Assembly (POA) to the hose) any time the joint is Removed and Reinstalled (R&R) for replacement or related service procedures. Clamps shall typically be replaceable with a loose clamp, without metallic retention clips, for service per DRE direction.

Elastomer hose joints with crimped style band clamps shall not be utilized in joints which much facilitate service R&R.

The use of dish soap or alcohol shall be allowable to clean the inside of the air hoses and dried prior to reinstall, per standard service procedures.

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

3.3 Design and Construction. A pressurized air elastomer hose band clamp joint will typically include the following componentry:

a. Elastomer hose, according to following manufacturing construction type:
    1. Construction type:
        a. Extruded hose.
        b. Wrapped hose.
    2. Design geometry (see Appendix A, Figure A6):
        a. Hose thickness x length (related to spigot length and band clamp width).
        b. Hose end internal chamfer or flared end (optional, for ergo install effort).
        c. Hose end perpendicularity.
        d. Alignment markings for clamp.
        e. Alignment markings to spigot.
b. Band clamp, according to the following part type:
    1. Worm drive band clamp per SAE J1508, Group Number 3, Type SLFEO, and per base clamp GM drawing 13433064 or equivalent.
        a. Retention and orientation features (see Appendix A, Figure A4):
            1. Pad mold (over molded/adhered elastomer block), preferred direction to avoid loose metallic clips.
            2. Metallic clip, only per DRE agreement/direction.
        b. Design geometry/features (see Appendix A, Figure A3):
            1. Clamp positioning (axial and radial) to hose.
            2. Metallic clips.
            3. Pad molds, per supplier best practice and DRE packaging approval.
    2. Crimp band clamp (optional) only per DRE direction, per supplier best practice.
        a. Design geometry:
            1. Minimal 12 mm width x 1.0 mm thickness.
            2. Position evenly between bead and stop.

3. Minimum crimping depth or force (in Product Quality Characteristic (PQC)) and location (Documentation Required (Standard Product Characteristic (DR)) to be added to drawing).

c. Spigot end-form (reference GM math data and drawing per XX079298):
   1. Construction type:
      a. Metallic machined (e.g., aluminum alloy).
      b. Metallic formed tubing (typically thin wall).
      c. Composite end form, with internal anti-crush ring.
         1. Anti-crush ring width x minimum thickness (See Appendix A, Figure A5 and Figure A10).
   2. Design geometry (see Appendix A, Figure A5 and Template Drawing XX079298):
      a. Barb/bead lead-in and retention geometry.
      b. Riblets (i.e., hose seal land).
      c. Hose seal land maximum parting line offset (composites only) ≤ 0.05 mm.
      d. Hose stop feature, 3 mm minimum height, and full 360 degrees.
      e. Hose orientation (i.e., 'clocking') alignment feature.

12 mm width band clamp is preferable in usage to 9 mm band clamp, in its ability to better resist 'coning', which may occur due to over-pressurization or pressure pulsation over time and may lead to premature joint failure (e.g., hose blow-off from spigot).

For metallic clip use, metallic clip positioning to be identified on hose assembly part drawing (see Appendix A, Figure A8) (reference GM Template Drawing XL111429, Sheet 1).

3.3.1 Materials, Processes and Parts Selection Guidelines.

3.3.1.1 Material Guidelines. Component materials shall be per the following requirements:

- Elastomer hose type, per GMW14726, GMW15408, or GMW16411 (see application specific Bill of Design (BOD) Level 1 SOR/CTS Appendix C and C.1 for requirement definition). For system with EGR, material compatibility shall be demonstrated by hose supplier.
- Anti-crush ring (composite spigot only): The steel ring material shall be SAE-ANSI 1008/1010 and anti-corrosion coating GMW3044 8k 240/96. For systems with EGR, the anti-collapse/crush ring shall be stainless steel GMW3161M-ST-S-X2CrNi18-9 (304SS).
- Band clamp:
  a. Worm drive style: SAE J1508, W4 (300SS), tested to ASTM B117 passing 400 with no red rust (i.e., Fe corrosion).
  b. Crimp style band clamp shall be 439 grade stainless steel.

Pad print ink material for hose identification and positioning (both hose to spigot and band clamp to hose) marking shall be (silicone based for silicone hoses) white or yellow color (for contrast to typical black hoses). Contrast. For alternative colored (i.e., than black) hose, other ink colors may be required, per applicable project DRE direction.

3.3.1.2 Processes Guidelines.

The elastomer hose, band clamp (worm drive), and spigot design shall facilitate the ergo effort assembly force and hand reach envelope requirements per GMW14234.

To ease assembly ergo effort concerns, the following assembly lubricants are allowed may be utilized:

- Deionized water.
- 9985406 Lubricant, Rubber (Diluted Material).
- 9985770 Lubricant, Rubber (P80).

Lubricant is typically brushed onto the hose end interior prior to assembly.

Band clamp, worm drive style, shall be aligned to target alignment markings, per Appendix A, Figure A10.

The band clamp, worm drive style, torque and drive speed shall be:

- 9 mm wide W4 hose clamp: Dynamic (D) 3.5 Nm ± 0.5 Nm, Static (S) 1.5 Nm to 3.5 Nm.

- Tool speed 300 rpm or less to 1.5 Nm, then 60 rpm or less to 3.5 Nm.
- 12 mm wide W4 hose clamp: D 5.5 Nm ± 0.5 Nm, S 2.5 Nm to 5.5 Nm.
- Tool speed 300 rpm or less to 1.5 Nm, then 60 rpm or less to 5.5 Nm.

The band clamp, worm drive style, drive socket clearance – socket OD plus 1 mm radial clearance shall be accommodated by the subsystem. Typical socket size (verify through Bill of Process (BOP) and Manufacturing Responsible Engineer (MRE)) is:

- 7 mm hex, ¼ in extension drive socket, OD = 12.7 mm.
- 7 mm hex, ⅜ in extension drive socket, OD = 19.1 mm.

3.3.1.3 Parts Guidelines. All components shall additionally be per applicable project specific SOR Appendix C/CTS part requirements. All composite spigots shall have internal metallic anti-collapse ring (see Appendix A, Figure A12).

3.3.2 Design Guidelines and Constraints.

3.3.2.1 Hose to Spigot Positioning. Hose to spigot hose stop feature shall typically be 360 degrees × 3 mm height, when able, per any packaging or manufacturing constraints, and shall include orientation (i.e., clocking) alignment feature (reference spigot GM Template Drawing XX079298).

3.3.2.2 Band Clamp to Hose Positioning. Band clamp to hose positioning shall be based upon band clamp width and Appendix A, Figure A7 and Figure A9 dimensions.

3.3.3 Identification and Marking. Elastomer hose to clamp interface and alignment markings, and elastomer hose to spigot orientation (i.e., clocking) alignment markings shall be per Appendix A, Figure A9. Markings shall be typically applied by part fixture-oriented pad print method. Marking color shall be white or yellow (see 3.3.1.1), unless otherwise specified or approved by project DRE.

Unless otherwise ultimately straight, uniform diameter, and aligned worm drive band clamps; assemblies shall have hose end mating component identification marking (see Appendix A, Figure A11). Suggested typical abbreviations are as follows:

- EGR = Exhaust gas recirculation system.
- ICAC = Indirect charge air cooler/heat exchanger.
- INT = Intake manifold.
- RES = Resonator.
- THR = Throttle body.
- TUR = Turbo.

Secondary abbreviations, if required for clarity:

- INLT = Inlet.
- OTLT = Outlet.
- Example: “ICAC OTLT”.

3.3.4 Workmanship. For subassemblies assembled on multiple components by the supplier, the subassembly as received by GM shall meet the component level cleanliness requirements per GMW18047.

Maximum elastomer hose cording fray length is 1 mm.

3.3.5 Interchangeability. Not applicable.

3.4 Documentation. All related documentation, drawings, specifications, and test reports shall be in International System of Units (SI) (metric) units. English or Imperial units are not acceptable.

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.

3.7.1 System/Subsystem/Component/Part Definition. Not applicable.

4 Validation

4.1 General. All parts should be labeled per the GM part number (e.g., 12345678AA or XX123456AA) and given sample number per the following test and sample definitions. The sample subsystem parts shall be label in a manner that the labeled endures the entire duration of testing.

For all testing routines, the smallest or Least Material Condition (LMC) tolerance range OD spigot, and largest or Maximum Material Condition (MMC) tolerance range ID hose, conditions shall be implemented when able. If these conditions cannot be met, the otherwise testing of nominal condition parts shall be approved by the applicable project DRE.

Attaching parts and/or representative materials and construction shall be utilized to represent the interfacing spigots.

All part interfacing dimension shall be fully characterized and recorded in the applicable test reports. At minimum but not limited to, these dimensional parameters shall be per the following:

a. Spigot:
    1. Riblets presence.
    2. Anti-collapse ring presence.
    3. Riblet OD.
    4. Bead OD.
    5. Overall Length.
    6. Material(s).
b. Hose:
    1. ID.
    2. Wall Thickness.
    3. Materials, number of layers, and construction type.
c. Band Clamp:
    1. Type.
    2. General Width.
    3. Band thickness.
    4. Clamp Range (i.e., mating part OD range).
    5. As shipped opening size.
    6. Clamp attachment method.
    7. Specific material.

The test personnel shall be trained in the facility and test related safety procedures and protocols.

4.2 Validation Cross Reference Index. The Air Delivery part applicable Validation Cross Reference Index (VCRI) shall be provided by the project DRE through the Project Development Team (PDT). The applicable project SOR Appendix C2 Life Test and VCRI Analysis, Development and Validation (ADV) Plan will specified whether the test duration or parameters shall supercede this document.

4.3 Supporting Paragraphs. Required Test Procedures. Test order sequence for shared test sample subsystem parts:

Pressure Pulsation Durability → Vibration Durability → Pressure Pulsation Highly Accelerated Life Test (HALT) testing

Note: Static Burst testing and the aged/non-aged new sample subsystem part portion of pressure pulsation HALT testing may be considered as standalone tests and may even be run prior or in parallel to standard durability testing as precursor or indicator to early failure, for any potential consideration for required engineering changes, prior to the investment of durability testing.

Pressure and temperature profile test parameters shall be per both CG6079 and applicable project SOR Appendix C2, unless otherwise specified per the SOR Appendix C1 or project applicable DRE.

4.3.1 Static Burst/Blow-Off Test. Static Burst testing is a standard test procedure and may be utilize as a metric for quick a to b comparisons, relative to any engineering design or material changes. Static burst testing is not a substitute for pressure pulsation over time testing.

4.3.1.1 Static Burst/Blow-Off Procedure. For static burst testing, the following hose conditions shall be included:

- Non-Heat Aged, quantity = Six (6).
- Heat-Aged 168 h. at 200 °C, quantity = Six (6).

Mount the interfacing components (e.g., elastomer hose, spigot, and band clamp), ensuring the hose if fully seated to representative hose stop, and torque to specified range. Free end of hose must be secured against leakage and blow-off, possibly requiring doubled clamp arrangement. Minimum subsystem sample size is twelve (12).

Spigot end form shall be representative of the design intent geometry, however shall be ultimately rigid, in effort to support proper leak check of hose and clamp portion of subsystem joint.

Testing shall be safety burst chamber and pressurized hydraulically with water, within a safety test chamber or tank, protecting the operator from part failure. Prior to testing, assembled joint shall be pressurized with air up to maximum boost pressure under water, to verify leak free connection verified with no bubbles (including champagne size). Alternative air leak pressure decay may be considered, as follows: maximum 20 cc/minute at 200 kPa, stabilize pressure at minimum of 20 s. Test temperature: Room Temperature (RT).

Increase pressure at a rate of 20 kPa ± 5 kPa/s per ASTM D380, Section 16 until either burst or leakage (i.e., monitored through pressurization monitoring system), joint separation, or discontinue at maximum pressure of 1 MPa (gauge).

Except in the cases of burst or joint separation (i.e., hose no longer connected to the hose), the distance the hose may have moved away from the representative hose stop shall be measured and recorded in the final test report.

- A graph of pressure vs. time shall be recorded and included, per each sample, in the final test report, unless there is otherwise DRE agreement.
- Verify band clamp is properly positioned per the parameters defined per 3.3.2.2.
- Torque worm drive band clamps per 3.3.1.2 and apply ink or paint mark across the band clamp fastener and housing (for later retained torque evaluation).
- Leak check each joint at maximum boost pressure +50 kPa and verify no leakage with joint under water at pressure. Air leak bubbles (including champagne size) are not acceptable. Test should not be started with any leakage.

EOT Checks:

- Leak check each joint at maximum boost pressure +50 kPa.
- Measure, photograph, and record distance hose may have slipped from physical hose stop.
- Upon joint teardown, inspect spigot and band clamp for signs of deformation, and inspect hose for any interior liner tears or delamination. Measure, photograph, and record and potential failure modes.
- Measure and record worm drive band clamp breakaway torque and torque-to-line values.

Passing Criteria is as Follows:

- Joint shall not exhibit hose/clamp blow-off, joint separation, or catastrophic damage. The minimum failure point pressure for all samples shall be 2x the maximum rated power or system working pressure, as defined through the project applicable SOR Appendix C.2.
- EOT leakage shall be: < 15 cc/minute, at maximum boost pressure +50 kPa and at RT, per DRE agreement.
- Clamp distance to bead not to be less than 1.5x hose wall thickness.
- No band clamp deformation or catastrophic damage.

4.3.2 Pressure Pulsation Durability Test and HALT to Failure. Pressure pulsation testing is the standard durability testing for the elastomer hose, spigot, band clamp joints. This testing is representative of one (1) life and has incorporated factors for over testing.

Pressure pulsation HALT (highly accelerated life test) to failure is both:

a. A sensitivity test for time to actual physical joint failure.

b. A metric for potential later a to b comparison contrasting potential engineering design or material changes. HALT may be utilized as a metric test point, to evaluate changes, and whether further full validation may be required – only per DRE agreement.

For the potential HALT contrast evaluations to be an effective means to potential avoid fully re-running durability validation, non-life test parts must have been included in the original engineering content test samples (i.e., samples 'a'). Non-durability shared HALT samples may be chosen to be run in parallel to durability testing, for early learnings or potential indicators for premature failure. A Soft HALT shall be considered as discontinuation of testing without failure, and strictly only per DRE agreement.

4.3.2.1 Pressure Pulsation Durability Test Procedure. The subsystem joint and parts shall be tested per Table 1.

Table 1: Pressure Pulsation Durability Requirements

Samples Number	Joint Condition	Total Cycles/Sample Note 1 (N/#)	Pressure (kPa)	Temperature Note 2
1 and 2	Dry	300 000 3 s high, 1 s low	ATM to Maximum Boost +50 kPa (absolute), per CG6079.	Per CG6079 Profiles TP1 for Post-iCAC. Per CG6079 Profiles TP2 for Pre-iCAC.
3 and 4	Lube			
5 and 6	Oil			

Note 1: Overall test time will be driven by the supplier's or test lab pressure equipment pulsation rate capability. This may typically be considered as approximately 6 s/cycle, dependent on test stand capability and overall air volume to fill and evacuate.
Note 2: A minimum total of thirty (30) excursion hours shall be met, whether included along with vibration, or solely as part of pressure pulsation testing.
Note: N/# = Cycle/Sample.

Sample Joint Conditions:

- Dry: Subsystem assembled dry (no assembly lube or oil added).
- Lube: Subsystem assembled with 9985770 (i.e., P80) assembly lube (see 3.3.1.2).
- Oil: Subsystem assembled with GMW17245 heat aged oil (reference Dexos2® 5W-30, part number 55573414, or equivalent per GMW16177).

  Lubricant and oil shall be brush applied at RT on the entirety of the hose interior ID surface which interfaces with the spigot (i.e., full length from end to hose stop).

Start of Test (SOT) Checks:

- Verify hose is fully seated to spigot hose stop upon joint assembly define per 3.3.2.1.
- Verify band clamp is properly positioned per the parameters defined per 3.3.2.2.
- Torque worm drive band clamps per 3.3.1.2 and apply ink or paint mark across the band clamp fastener and housing (for later retained torque evaluation).
- Leak check each joint at maximum boost pressure +50 kPa and verify no leakage with joint under water at pressure. Champagne and larger size bubbles are not acceptable. Test should not be started with any leakage.

EOT Checks:

- Leak check each joint at maximum boost pressure +50 kPa.
- Measure, photograph, and record distance hose may have slipped from physical hose stop.

- Upon joint teardown, inspect spigot and band clamp for signs of deformation, and inspect hose for any interior liner tears or delamination. Measure, photograph, and record and potential failure modes.
- Measure and record worm drive band clamp breakaway torque and torque-to-line values.

Passing Criteria is as Follows:

- Joint shall not exhibit hose/clamp blow-off, joint separation, or catastrophic damage.
- EOT leakage shall be: < 15 cc/minute, at maximum boost pressure +50 kPa and at RT.
- No band clamp deformation or catastrophic damage. Minimum retained torque shall be reviewed with band clamp supplier for review and feedback.

4.3.2.2 Pressure Pulsation Test (HALT) Procedure. A portion of the HALT pressure pulsation test samples shall be carried over from the pressure pulsation durability testing, according to the sample numbers as illustrated in the test matrix table, whereas additional new (i.e., not-yet-tested) parts shall be additional introduced to the testing.

The subsystem joint and parts shall be tested to failure per Table 2.

Table 2: Pressure Pulsation Test Requirements

Samples Number	Joint Condition	Cycles/Pressure/Sample and Total Cycles/Sample Note 1 (N/#)	Pressure (kPa)	Temperature Note 2
2 and 7	Dry	100 000/Pressure (increments) 300 000/Sample 3 s high, 1 s low.	ATM to Maximum Boost +100 kPa/150 kPa/200 kPa (absolute), per CG6079.	Per CG6079 Profiles TP1 for Post-iCAC. Per CG6079 Profiles TP2 for Pre-iCAC.
4 and 8	Lube			
6 and 9	Oil			

Note 1: Overall test time will be driven by the supplier's or test lab pressure equipment pulsation rate capability. This may typically be considered as approximately 6 s/cycle. Minimum number of cycles before failure shall be 10 000, Soft HALT may be considered at 300 per DRE agreement only.
Note 2: Template temperature profiles per CG6079 shall be reviewed with DRE on program applicable basis and may need to be adjusted accordingly. Constant elevated temperature may be considered based upon supplier recommendations, and only per DRE agreement.

For sample joint conditions, SOT and EOT checks (see 4.3.2.1).

Failed part test conditions, number of cycles, and photographs of failure modes shall be recorded to test report.

4.3.3 Vibration Test. Elastomer hose systems with two (2) or more convolutes, 75 mm or more distance, include significant bends of ≤ 160 degrees in the routing between spigots, or contain one (1) or more anti-dilation rings, shall be vibration tested.

Vibration testing shall be conducted with same pressure pulsation samples, after pressure pulsation durability and prior to HALT testing, according to the sample numbers as illustrated in the test matrix table.

Note: A supplier may combine pressure pulsation and vibration durability testing into one (1) common test, if given test equipment is capable of doing so. If combining the test, the total number of excursion temperature hours shall remain at minimum 30 h, and the full pressure pulsation cycles and vibration test hours, whichever comes last, shall be completed.

For tests in series, joint assembly shall not be performed until all testing (including pressure pulsation) is completed.

4.3.3.1 Vibration Test Procedure. The subsystem joint and parts shall be tested per Table 3.

Table 3: Vibration Test Requirements

Samples Numbers	Joint Condition	Total Time (hours)	Vibration Profile Note 1	Temperature Note 2
1 and 2	Dry	200 h	To be provided by DRE, per specific engine application physical vibration data.	Per CG6079 Profiles TP1 for Post-iCAC. Per CG6079 Profiles TP2 for Pre-iCAC.
3 and 4	Lube			
5 and 6	Oil			

Note 1: Z-Axis minimum and/or others as required per DRE evaluation.
Note 2: A minimum total of thirty (30) excursion hours shall be met, whether included along with vibration, or solely as part of pressure pulsation testing.

Sample Joint Conditions:

- Dry – Subsystem assembled dry (no assembly lube or oil added).
- Lube – Subsystem assembled with 9985770 (i.e., P80) assembly lube (see 3.3.1.2).
- Oil – Subsystem assembled with GMW17245 heat aged oil (reference Dexos2®5w30, part number 55573414, or equivalent per GMW16177).

  Lubricant and oil shall be brush applied at RT on the entirety of the hose interior ID surface which interfaces with the spigot (i.e., full length from end to hose stop).

SOT Checks:

- Verify hose is fully seated to spigot hose stop upon joint assembly define per 3.3.2.1.
- Verify band clamp is properly positioned per the parameters defined per 3.3.2.2.
- Torque worm drive band clamps per 3.3.1.2 and apply ink or paint mark across the band clamp fastener and housing (for later retained torque evaluation).
- Leak check each joint at maximum boost pressure +50 kPa and verify no leakage with joint under water at pressure. Air leak bubbles (including champagne size) are not acceptable. Test should not be started with any leakage.

EOT Checks:

- Leak check each joint at maximum boost pressure +50 kPa.
- Measure, photograph, and record distance hose may have slipped from physical hose stop.
- Upon joint teardown, inspect spigot and band clamp for signs of deformation, and inspect hose for any interior liner tears or delamination. Measure, photograph, and record and potential failure modes.
- Measure and record worm drive band clamp breakaway torque and torque-to-line values. Minimum retained torque shall be reviewed with band clamp supplier for review and feedback.

Passing Criteria is as Follows:

- Joint shall not exhibit hose/clamp blow-off, joint separation, or catastrophic damage.
- EOT leakage shall be: < 15 cc/min, at maximum boost pressure +50 kPa and at RT.
- No band clamp deformation or catastrophic damage.

4.3.4 Clamp Pull-Off. In axial direction, band clamp (i.e., whether retained with metallic clips, vulcanized patch, or adhesive), shall resist up to 335 N axial to hose pull-off force (see Figure A14 for example test set-up). Test sample quantity is minimum of six (6) for both DV and PV.

4.3.5 Load Evaluation. For elastomer hoses, which are known to potential apply axial expansion or contraction and rotational load into adjoining subsystems, the supplier shall characterize (early analytical accepted, and empirical physical testing is required) the hose relative to maximum operating pressure plus 50 kPa for both axial contraction or extension and rotational loading. The evaluation shall be performed with one end of the hose grounded and the other end utilized for load measurement. This resulting data shall be provided and updated to the applicable DRE throughout the project for input to the adjoining subsystem components, with first analytical

data sample being provided no later than 14 weeks prior to program Beta Product and Process Design Review (PPDR).

4.3.6 Corrosion. As applicable for metallics, part shall pass requirements per:

- GMW14671 corrosion performance for parts with organic coating.
- GMW14872 all parts cyclic corrosion test.
- GMW15272 all parts as applicable, corrosion performance specification requirements.

Surrogate corrosion acceptable, as appropriate, and only per DRE agreement.

5 Provisions for Shipping

5.1 Clamp Position as Shipped. The elastomer hose assembly with POA worm drive style band clamp, shall be shipped in the open (i.e., ready to install) position. This position shall be in an open diameter that shall not hinder the ergo effort install of the elastomer hose over the spigot end bead and fully (i.e., seated to hose stop) onto the spigot. The proper open position shall be illustrated on the hose assembly engineering release drawing.

The clamp shall be attached per the hose end positioning (longitudinal) location and orientation (axial clocking), and this positioning and orientation shall be fully defined per the hose assembly engineering release drawing.

The positioning and orientation shall be designed and defined in the ready to fasten location, and to fully support manufacturing installation for proper tooling access (see Appendix A, Figure A13).

The clamp shall be attached to the elastomer hose per the defined metallic clip, pad mold, or adhesive methods, and the supplier shall ensure the clamp retention and positioning survives standard shipping methods without becoming unattached or out of proper position.

5.2 Containerization and Dunnage. Shipping caps may be required per DRE direction, and shall be defined on the assembly part drawing. Bulk poly bag may be allowed for contamination concerns during shipping, but only per DRE direction and receiving manufacturing assembly plant agreement.

6 Notes

6.1 Glossary.

ATM: Atmospheric Pressure (Detroit region example: typically, 101.325 kPa at 20 °C**,** dry air)

6.2 Acronyms, Abbreviations, and Symbols.

ADV	Analysis, Development and Validation
BOD	Bill of Design
BOP	Bill of Process
CTS	Component Technical Specification
DR	Documentation Required (Standard Product Characteristic)
DRE	Design Release Engineer
DV	Design Validation
EGR	Exhaust Gas Recirculation
EOT	End of Test
HALT	Highly Accelerated Life Test
iCAC	Indirect Charge Air Cooler (i.e., air to liquid heat exchanger)
ID	Inner Diameter
IMDS	International Material Data System
LMC	Least Material Condition
MMC	Maximum Material Condition
MRE	Manufacturing Responsible Engineer
N/#	Cycle/Sample
OD	Outer Diameter

PCV	Positive Crankcase Ventilation
PDT	Project Development Team
POA	Part of Assembly
PPDR	Product and Process Design Review
PQC	Product Quality Characteristic
PV	Process Validation
R&R	Removed and Reinstalled (service related)
RT	Room Temperature, typically 20 °C ± 3 °C
SI	International System of Units
SOR	Statement of Requirements
SOT	Start of Test
VCRI	Validation Cross Reference Index

7 Additional Paragraphs

7.1 All materials supplied to this standard must comply with GMW3059, **Restricted and Reportable Substances**, including the requirement to submit a full material composition disclosure to GM via the International Material Data System (IMDS).

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

GMW18182

9 Release and Revisions

This standard was originated in June 2019. It was first approved by Powertrain - Global Engine Hardware Engineering in September 2019. It was first published in October 2019.

Issue	Publication Date	Description (Organization)
1	OCT 2019	Initial publication.
2	MAY 2020	Update to add CG6079. (Powertrain - Global Engine Hardware Engineering)

Appendix A: Illustrations of Design Requirements

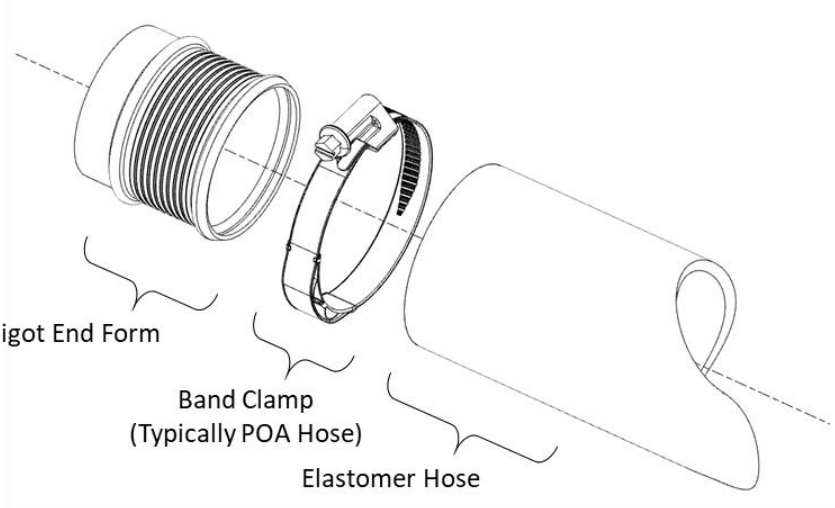

Figure A1: General Subsystem Components Illustration (exploded view)

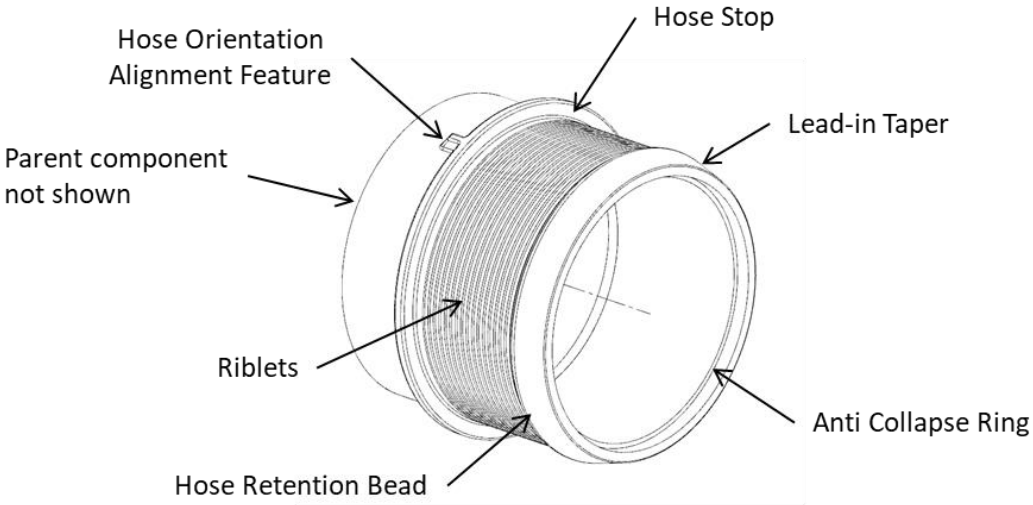

Figure A2: Spigot End-Form Features

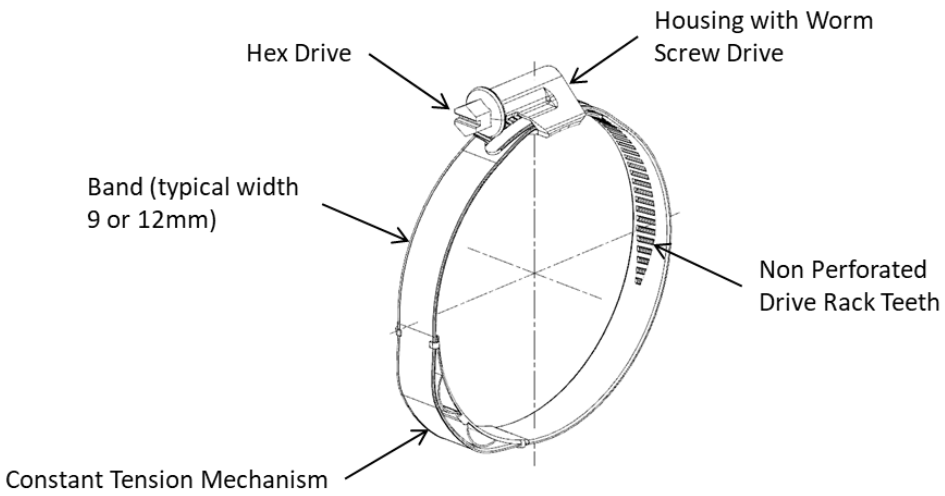

Figure A3: Band Clamp (Worm Drive) Features

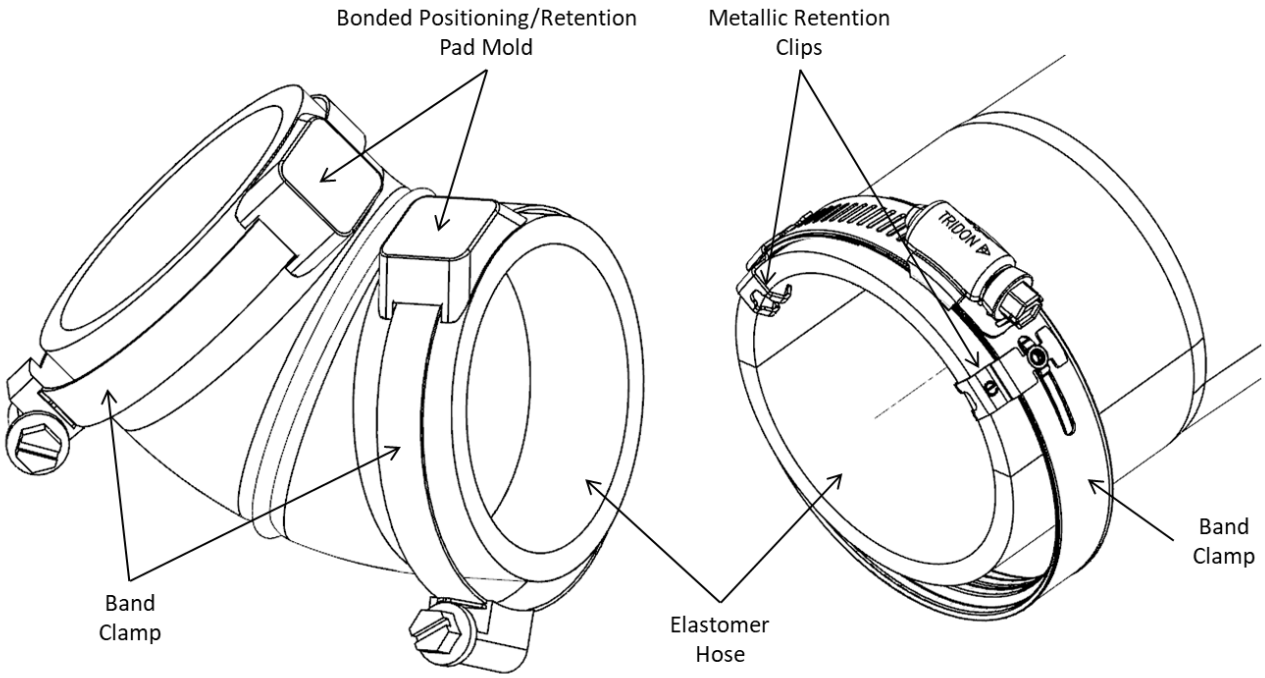

Figure A4: Band Clamp (Worm Drive) to Hose Retention Features

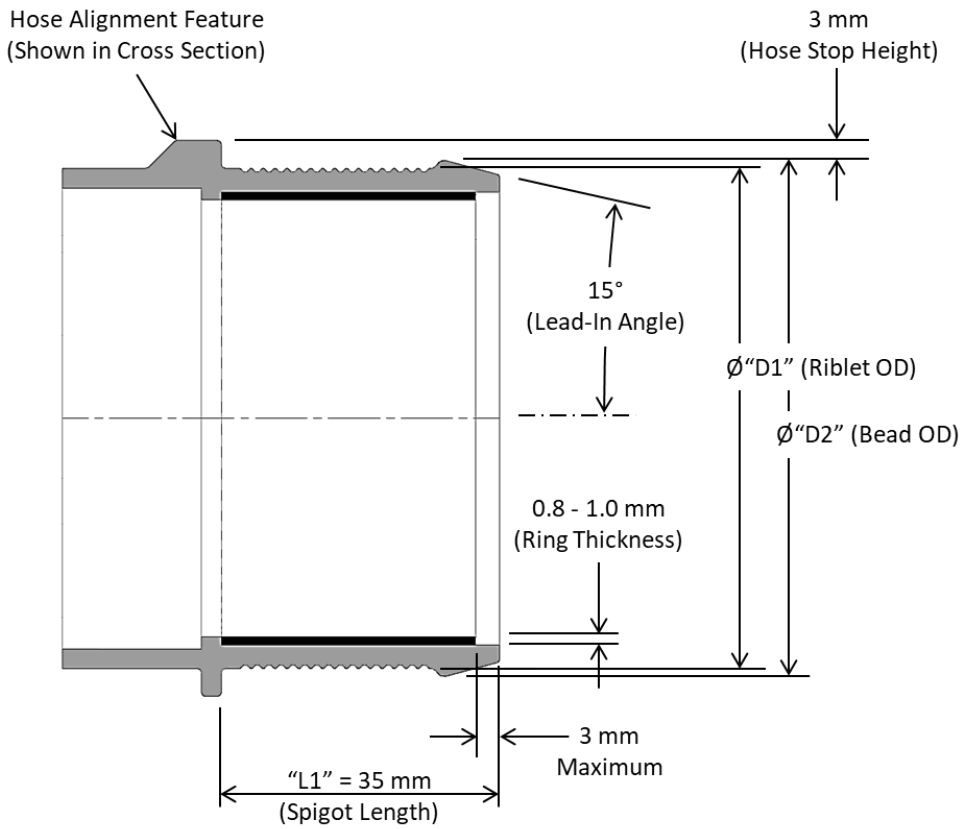

Figure A5: Spigot End-Form Design Requirements
(See Teamcenter NX Template Drawing XX079298.)

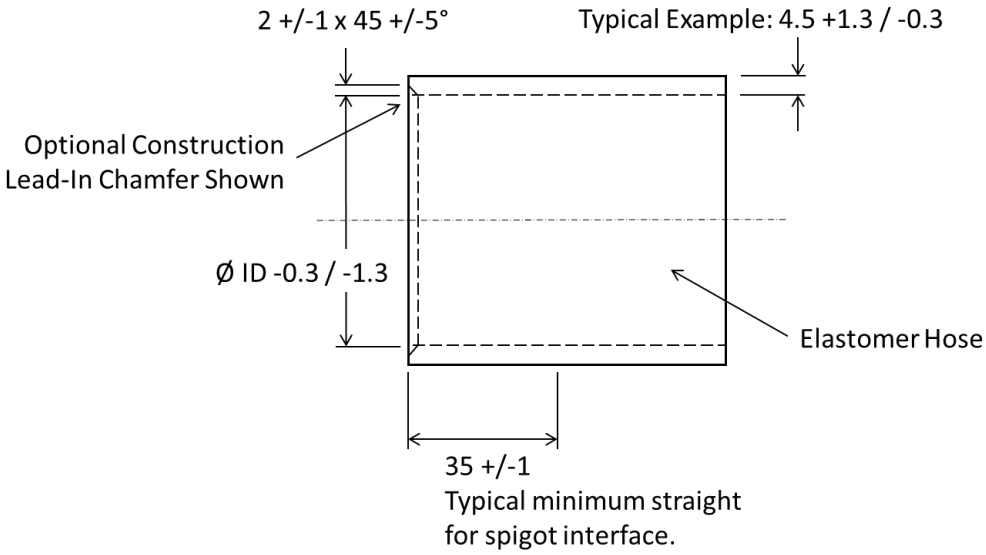

Figure A6: Hose End Design Requirements

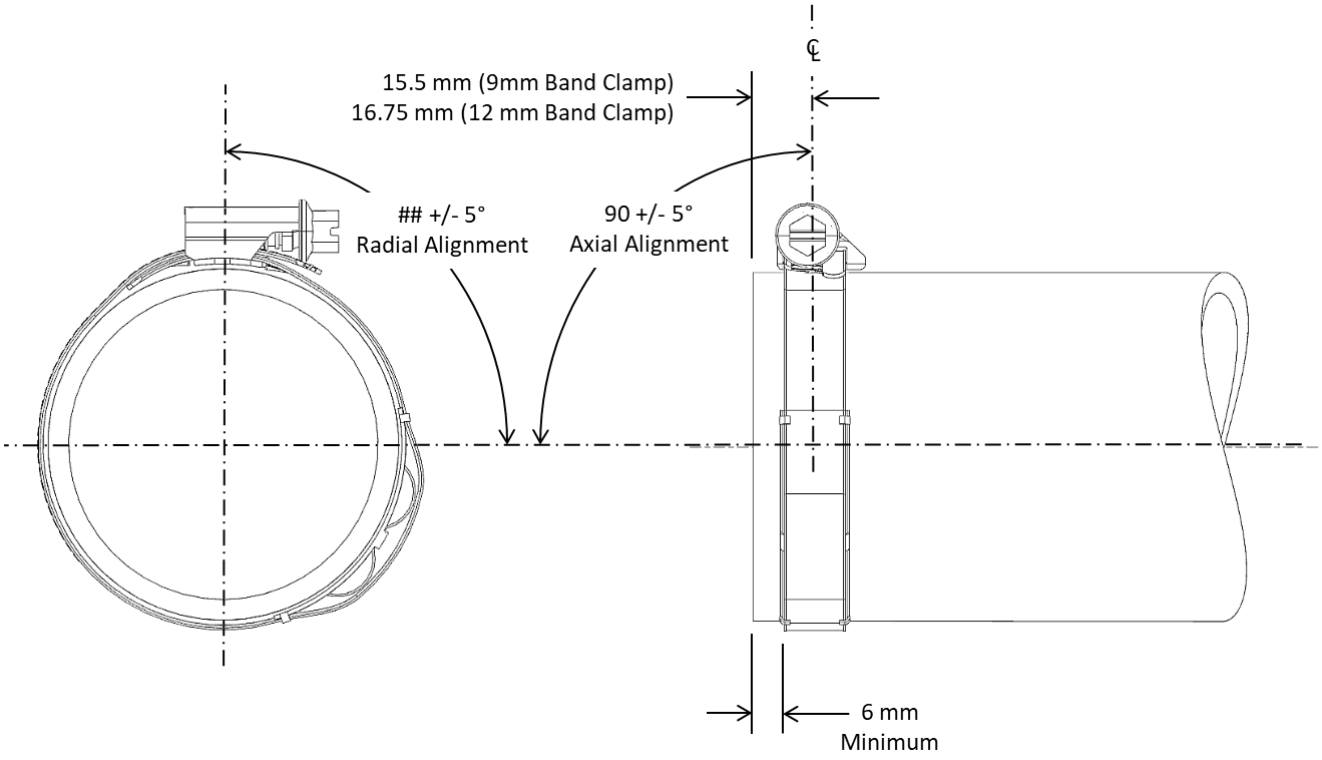

Figure A7: Band Clamp (Worm Drive) to Hose Position and Orientation Requirements

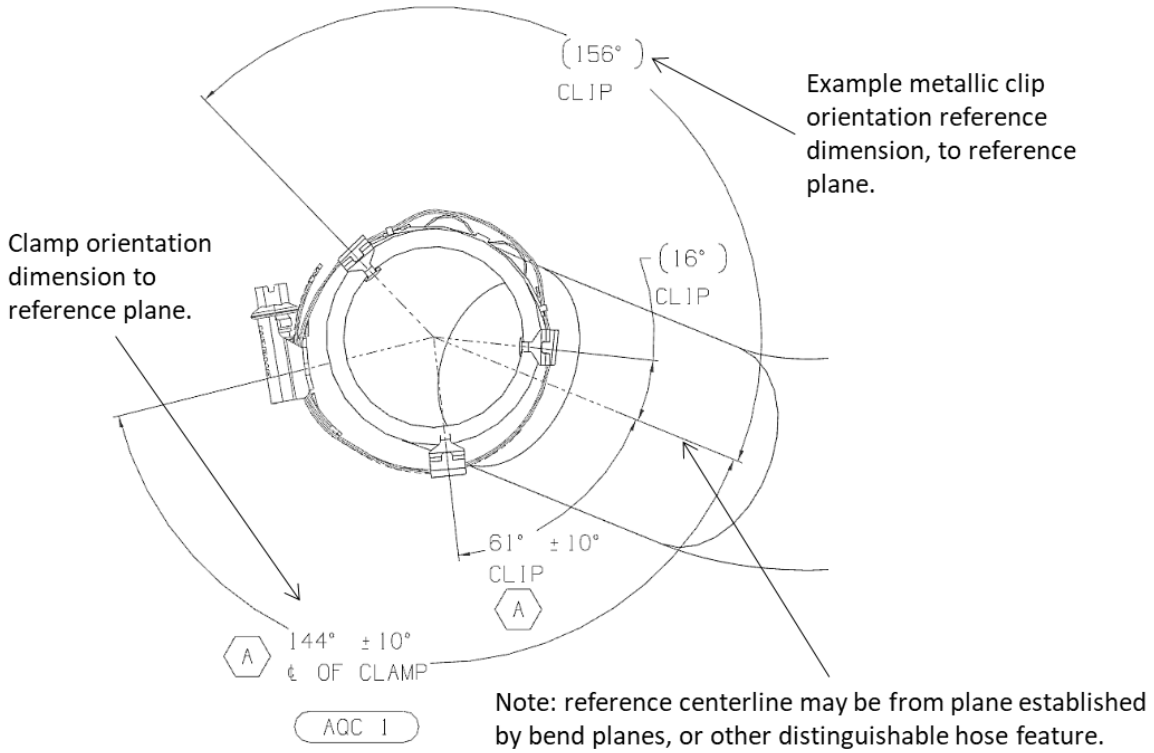

Figure A8: Example Band Clamp Clip Orientation

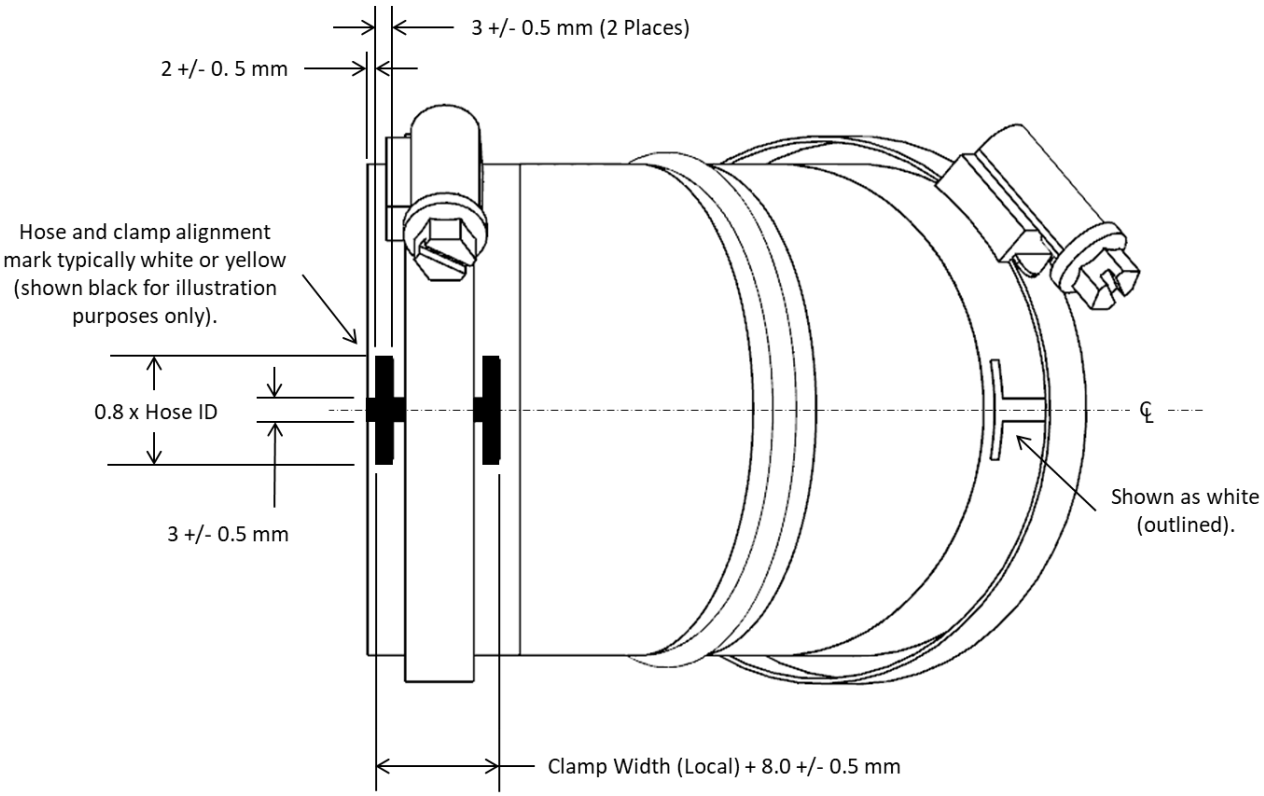

Figure A9: Hose to Band Clamp (Worm Drive) Position and Alignment Marking Requirements

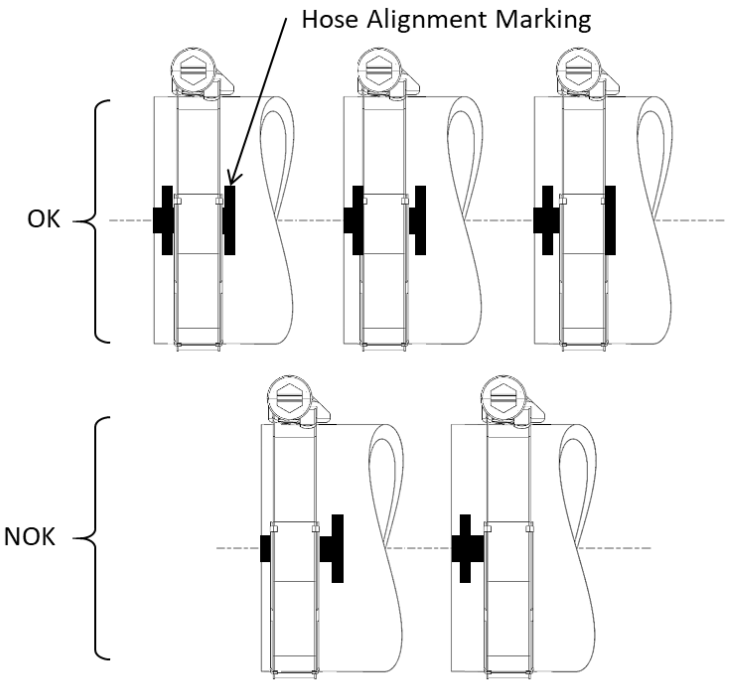

Figure A10: Clamp Alignment Acceptable Range

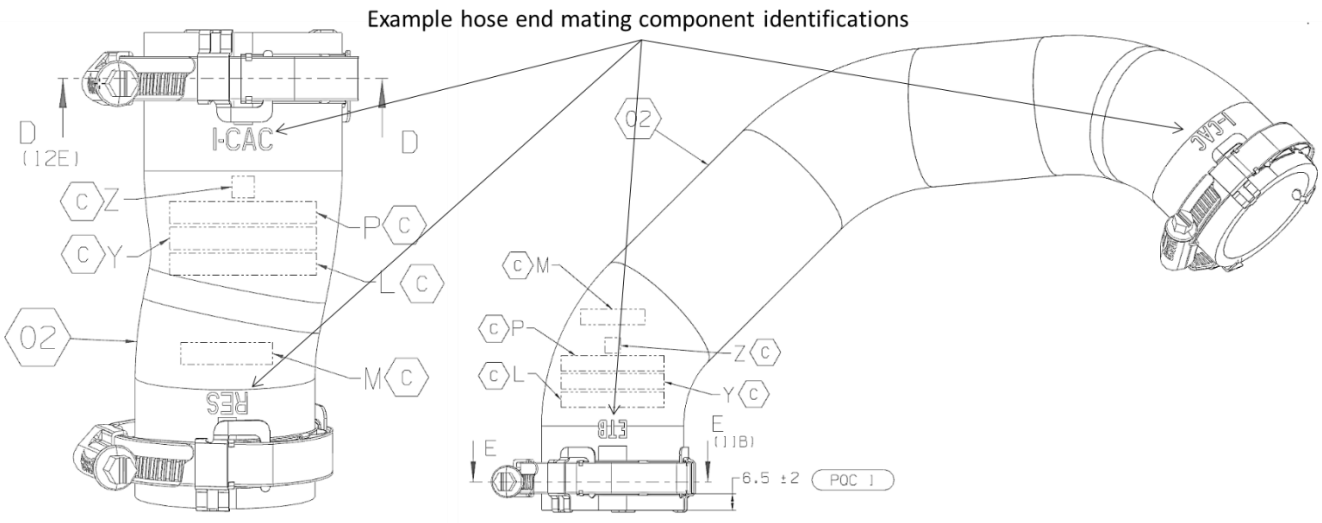

Figure A11: Example Hose End Mating Component Identifications

Figure A12: Example Spigot Deformation (Failure)

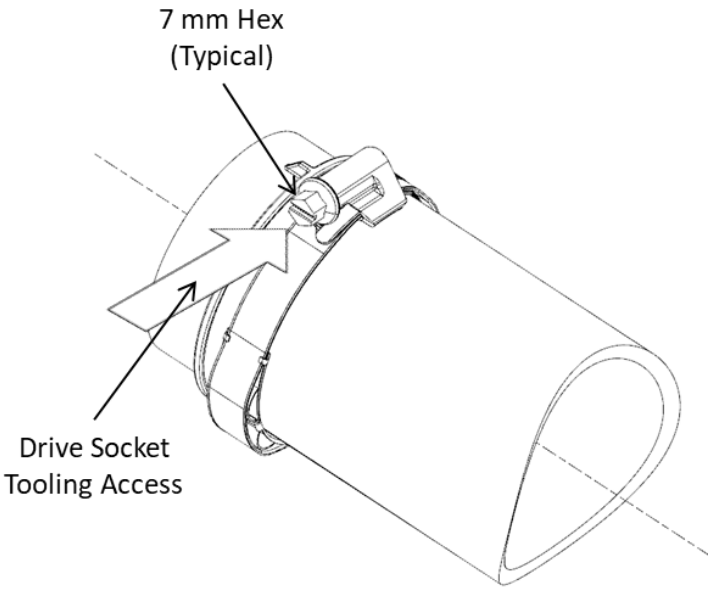

Figure A13: Band Clamp (Worm Drive) Tooling Access

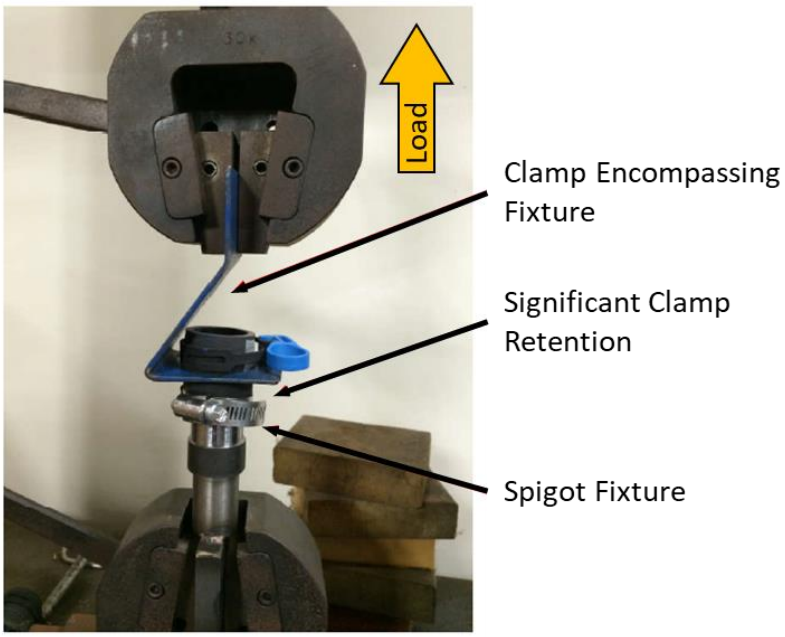

Figure A14: Example Clamp Pull-Off Test Set-Up