IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Danfoss Journal Bearing Removal

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Client: Danfoss Power Solutions, 300 Airport Road, Ames, IA, 50010. www.Danfoss.com

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- Tristan Jones, Process Engineer, Parts and Service, tjones@danfoss.com, 515-509-4564

1 PROBLEM STATEMENT

Danfoss Power Solutions is a global leader in the mobile hydraulic power market. As a key supplier to some of the world's most recognized names in construction and agricultural machinery, Danfoss's market share includes remanufactured hydraulic pumps and motors. Parts and Service is responsible for producing these remanufactured units and continues to encounter and overcome challenges unique to remanufacturing. One such problem is the removal of journal bearings from the pump and motor castings.

Journal bearings are thin, press-fit bushings that provide a bearing surface for shafts in low load locations. Most bearings are installed in blind holes with little clearance between the bottom of the bearing and the bottom of the hole. Traditional removal methods are insufficient to remove them effectively, and so removal is accomplished by deforming the bearing in place with a cold chisel and repeated blows with a hammer until the bearing can be pried out of the bore with pliers. This method creates the following problems:

- Bad ergonomics and potential injury risk
- Potential contamination of the workbench and unit under assembly

- Potential damage to the casting
- Time-consuming
- Requires skill

Approximately 2000 bearings are removed annually, in 8 sizes and in a wide variety of parts. An upcoming process change will increase the number of bearings removed by over 30%. Furthermore, the removal process is currently done by highly skilled assembly technicians, but there is a desire to move the process to the “teardown” room to consolidate disassembly operations where the teardown technicians are typically less skilled. All of these factors contributed to prioritizing a solution to this problem.

2 Goal Statement

The main objective is to develop and implement an improved method of removing the bearings through a typical or novel application commercially available solutions, custom designed tooling, or a combination of both. Specific objectives include:

- Elimination hammer and chisel method
- Elimination of potential damage to castings
- Significant reduction in contamination risk
- 30% reduction in removal time
- Easy for new employees with minimal training

When complete, an effective solution will significantly reduce the risk of injury, thereby improving morale and increasing productivity. Damage prevention will reduce the risk of premature product failure at the end user and safeguard the brand’s reputation. Reduction in removal time has the potential to save up to $4200 annually.

The scope of the project includes quantifying the current process, identifying potential solutions, procure or design and fabricate tooling as applicable, test, measure, and implement. The scope of the project excludes custom design of safety equipment for powered tooling, as well as the details of removal duties being transferred from one department to the other. Finally, the project is limited to one product line: Series 90 pumps and motors

3 Project Plan/Outline

Throughout the entirety of this project, our group used many different reference materials to help guide our path to find a solution. We referenced:

- Tool catalogs
- Automotive specialist
- Bearing removal processes
- Specialty tool consultants

Tool catalogs were the main reference we used from the start. Using catalogs as a reference made it easier to broaden our horizons on all of the current bearing removal tools. Referencing different types of bearing removal processes also helped in our goal to find the proper tooling and how we were going to fixture our solution. Referencing automotive specialists and specialty tool consultants helped on deciding the best tools and processes for removal of bearing races.

These goals are also our content for data collection once we have finalized our solution. Completion of testing will show the results of our 30%-time reduction and overall safety hazard reduction. This data will be measurable through time studies and safety analysis of the bearing removal solution.

Skills utilized throughout this project have been hazard identification, AutoCAD, manufacturing, fabrication, and utilizing lean processes. All of these skills have played a significant role in not only the solution to our project but also in our data collection and planning.

The solution of this project was created through extensive research and repurposing a current process of bushing removal completed at Danfoss. This solution was tested through functionality and time studies of the current process. Technician Interviews to help gain information on what the current solution lacked and what they would find useful was also a big help in shaping our solution. We knew our final solution would cut down cost and overall process time while efficiently eliminating safety hazards to the technician. Throughout the entirety of this project, our client has been in constant review and inspection of our solution. All of our client's feedback and suggestion were involved in our final solution.

Organization of our project and meeting times was determined by our group. Client meetings were held every Friday at 9:30 am. Our team workloads were determined by a tentative schedule in our group report. When it came to keeping on schedule, we had setbacks due to the implementation of different ideas, but setbacks we overcome by breaking up the workload and seeking alternatives.

Following our timeline sometimes led to restructuring due to setbacks. Setbacks, unfortunately, are part of the creative developmental process and occur when trying new solutions. However, our group overcame our setbacks and hard deadlines were set in able to ensure advancement towards our solution.

4 Results

The original deliverables for the project included:

1. Summary of current process costs
2. Procurement and/or prototype of tooling
3. Drawings of any custom tooling
4. If applicable, fabrication of tooling
5. Training material and standard work

The deliverables are consistent with project objective and scope, but not all deliverables were completed. As the multiple potential solutions were determined to be ineffective, fabrication of custom tooling became impractical in the remaining time.

Our final recommendation is to use a pneumatically compensated balanced arm to support a hydraulic cylinder. The cylinder applies a pulling force to one of several custom end effectors to remove the bearings. Each end effector is sized specifically for the bearing it is to remove, and interfaces with the cylinder through a quick-change mechanism that makes installing and changing end effectors fast and simple. A full set of drawings, bill of materials, and hydraulic schematic can be found in the appendix.

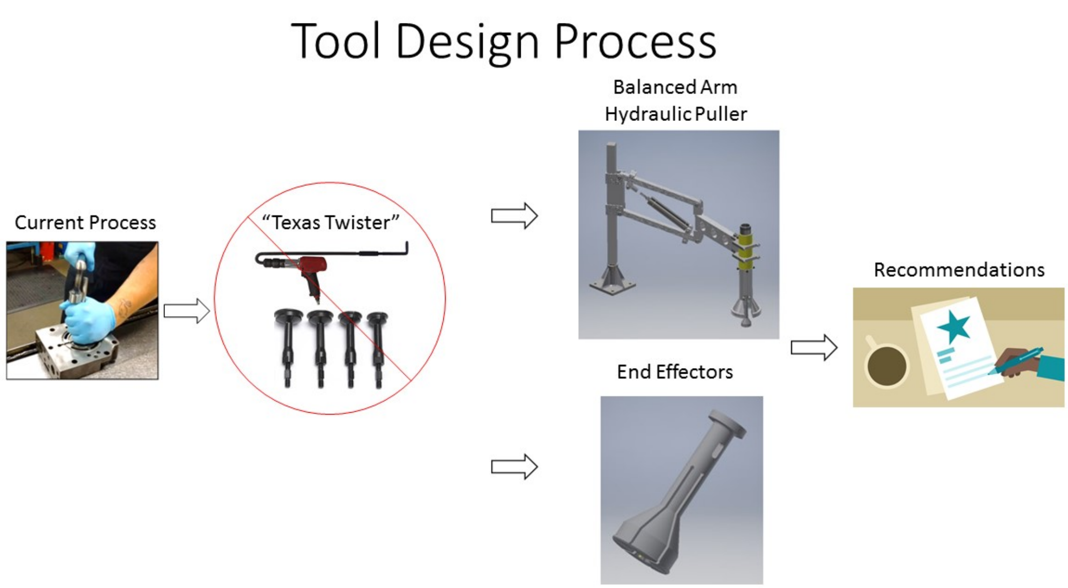
5 Broader Opportunity Statement

Beyond the economic considerations, solving this problem simply makes the Airport Road facility a better place to work. Pulling bearings is a dreaded task, and an improved method will be met with enthusiasm.

While the specific problem of pulling journal bearings from blind holes is not common, it is also not unique. A key customer of ours also does remanufacture work, and they use a similar method of bearing removal to the unimproved Danfoss method. During a recent tour, they expressed hope to learn a better way of performing this task.

Improving the bearing removal process potentially increases in the quality of the products we produce. Quality is A key priority for Danfoss, and they take pride in providing reliable remanufactured units to cost-conscious customers. The improved quality helps these customers continue to reduce their total cost of ownership for their equipment, reduce downtime, and continue to produce the food, buildings, and infrastructure we rely all on upon.

6 Graphical Abstract



7 References

Daines, James R. 2013. *Fluid Power: Hydraulics and Pneumatics.* Tinley Park: Goodheart-Willcox.

Danfoss Power Solutions. 2019. *Internal Electronic Resources.* Ames.

Oberg, Erik, Franklin Jones, Holbrook Horton, Henry Ryffel, and Christopher McCauley. 2016. *Machinery's Handbook, 30th. Edition.* South Norwalk: Industrial Press.

Unnamed, interview by Lucas Kramer. 2019. *SKF Product Engineer* (02 12).

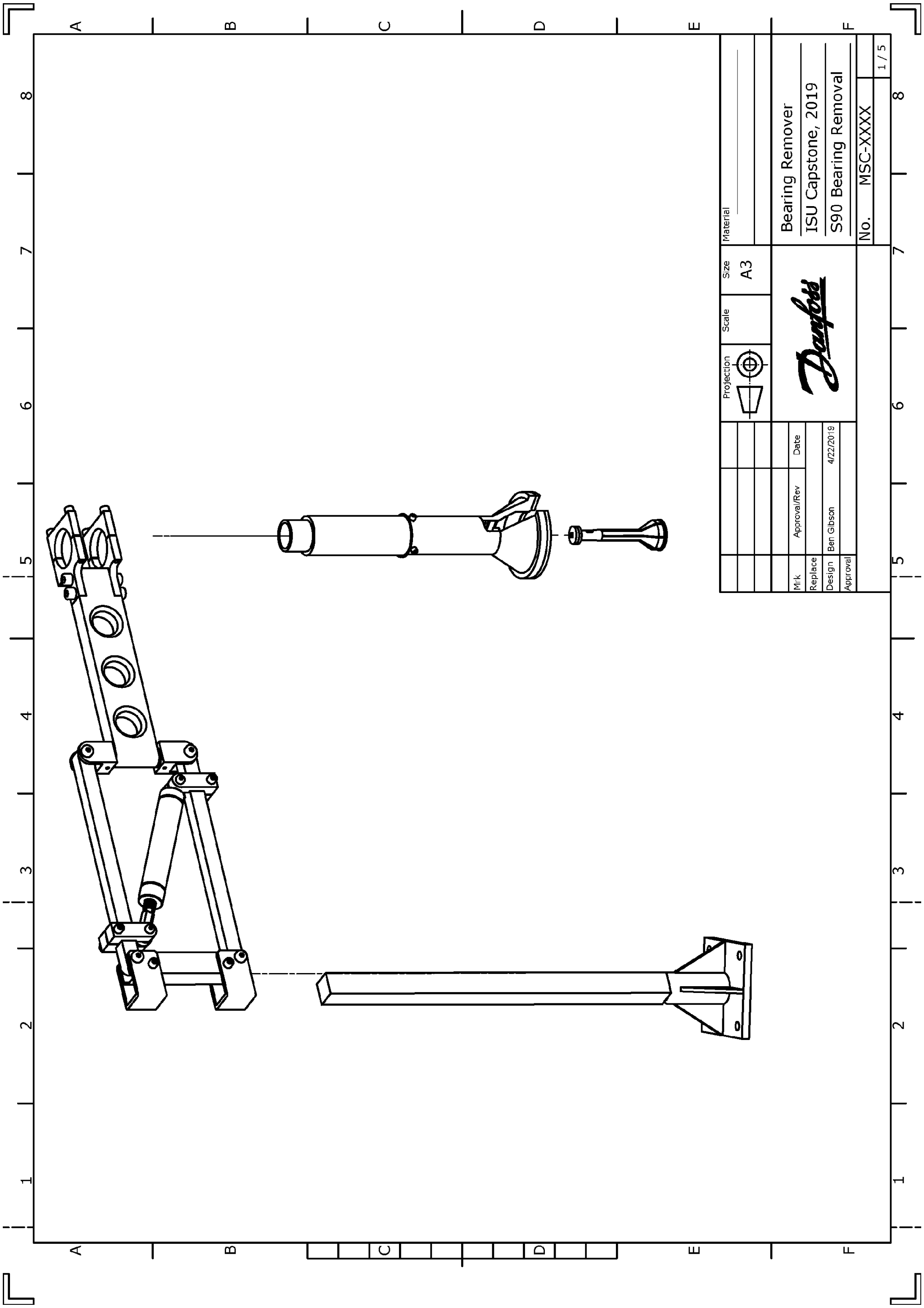
8 Appendixes

Appendix A: Part Drawings

Appendix B: Bill of Materials

Appendix C: Hydraulic Schematic

APPENDIX A - DRAWINGS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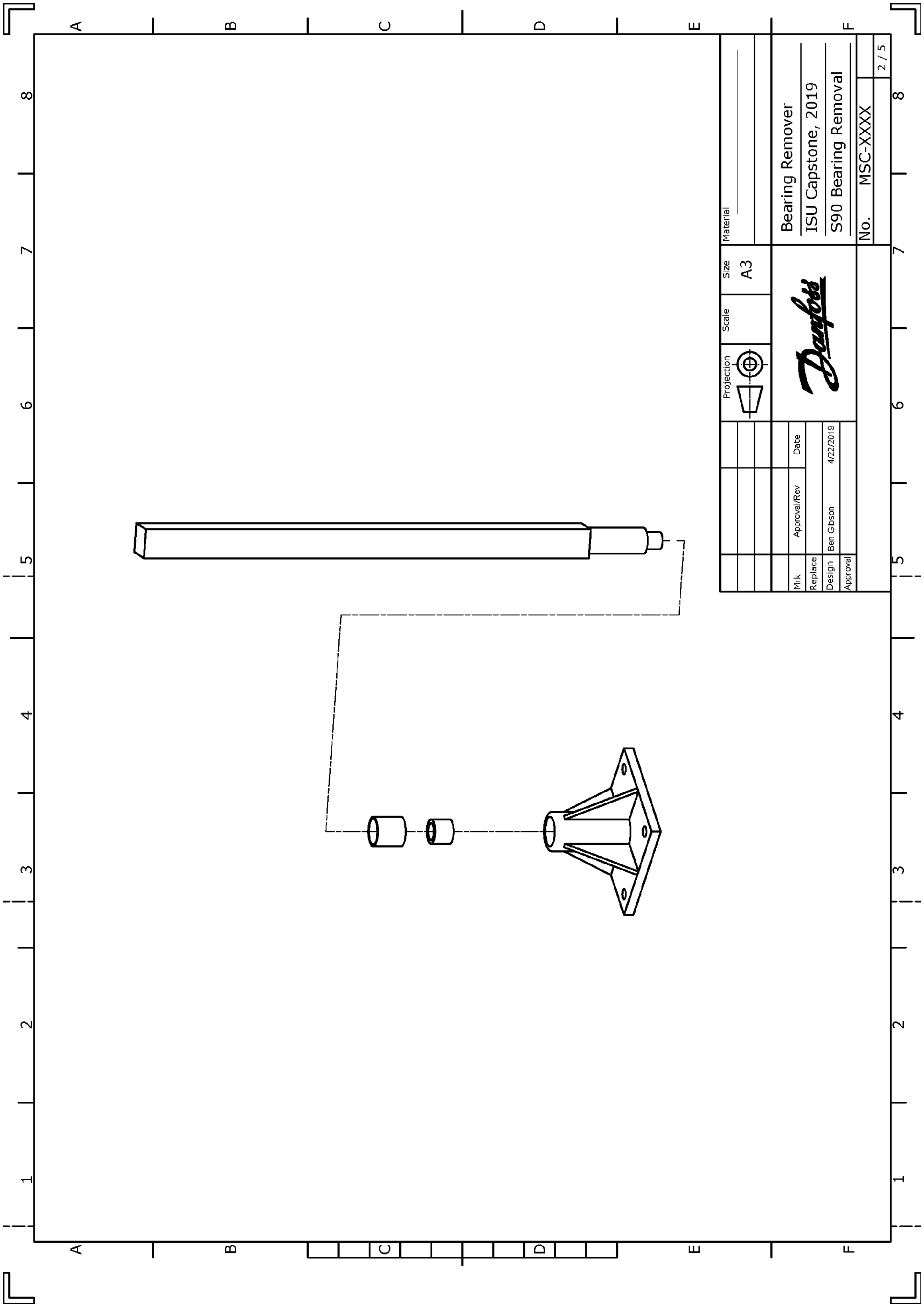
Design
Approval
Approval/Rev
Ben Gibson
Date
4/22/2019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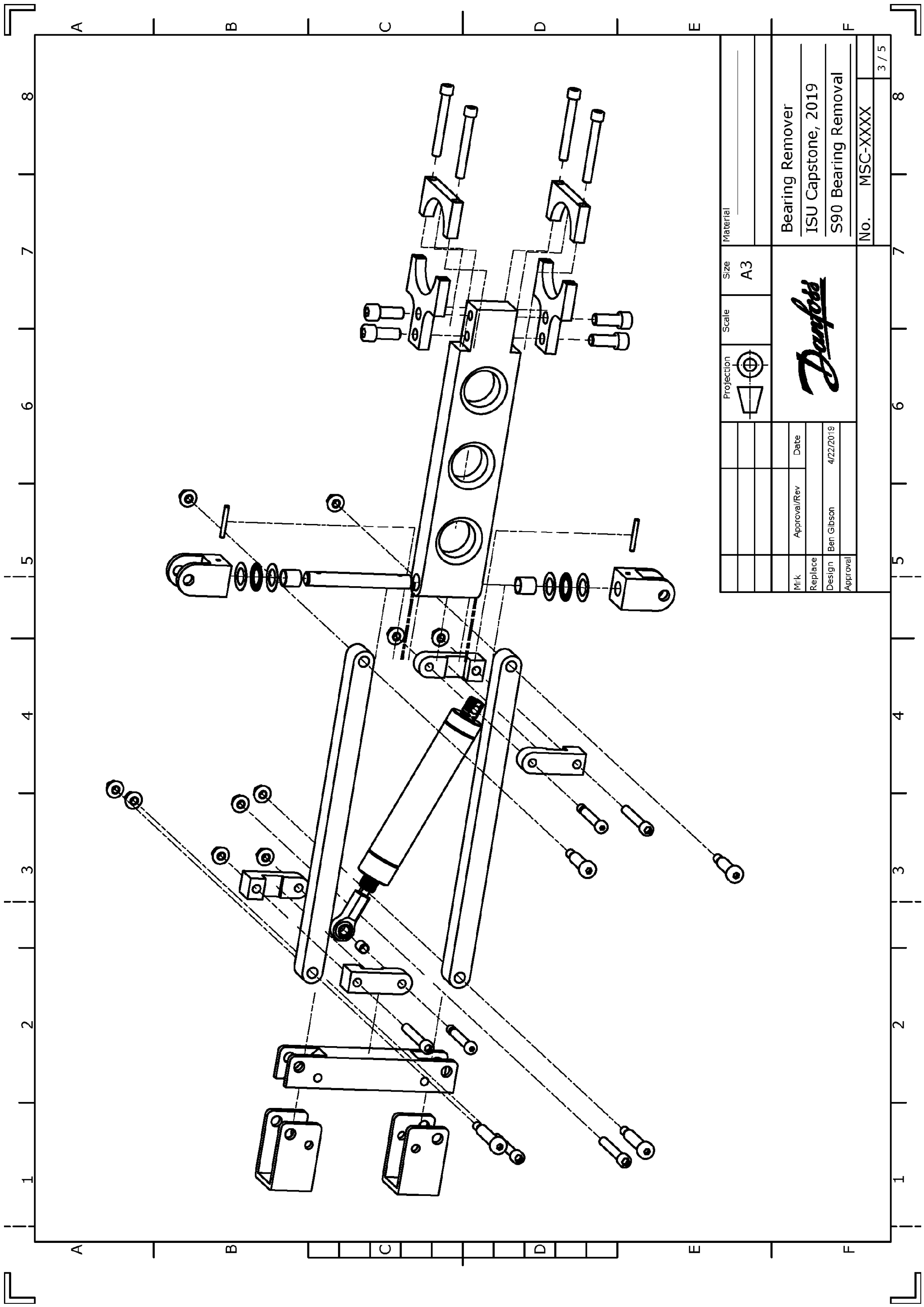
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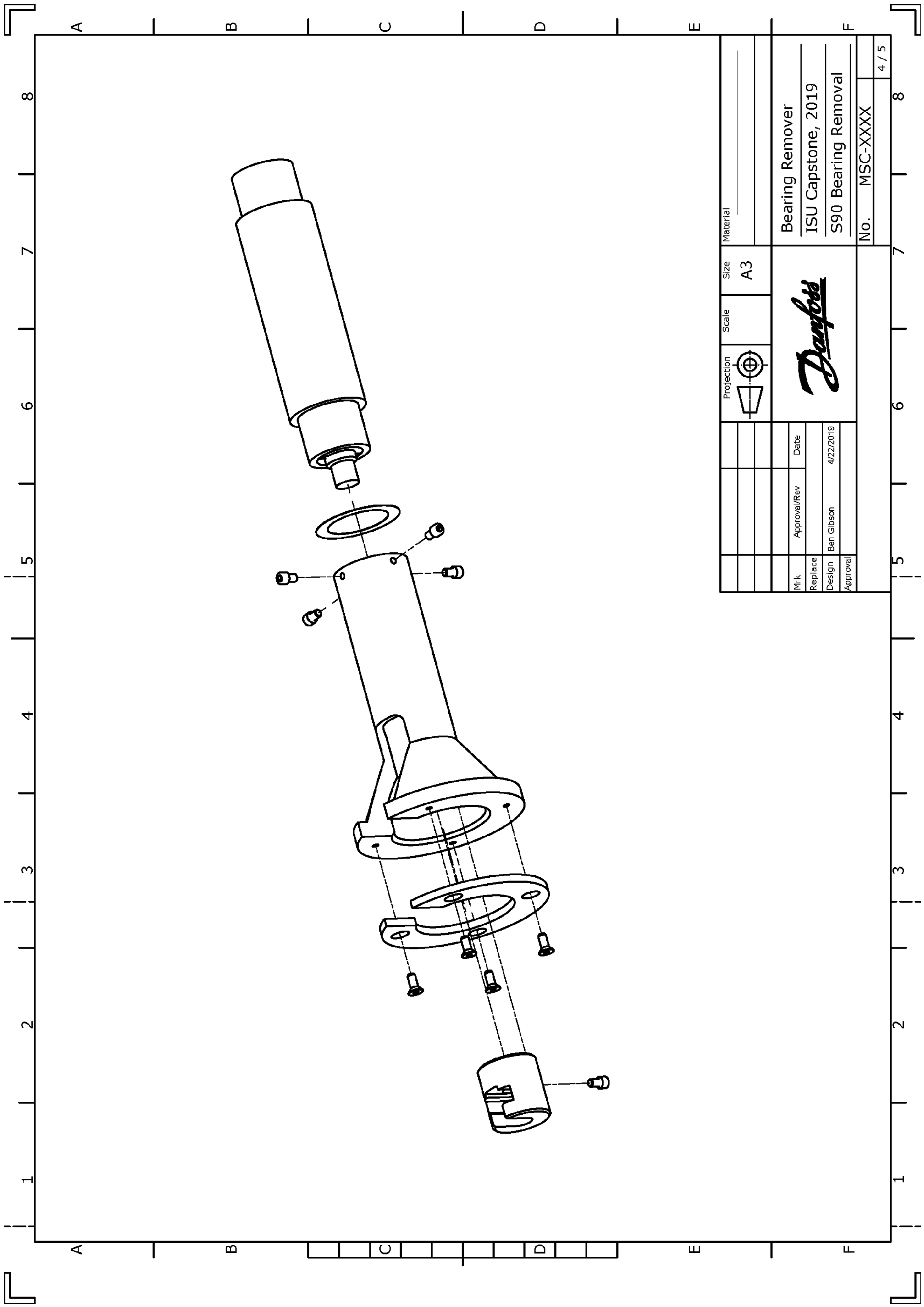
Ben Gibson
4/22/2019
Danfoss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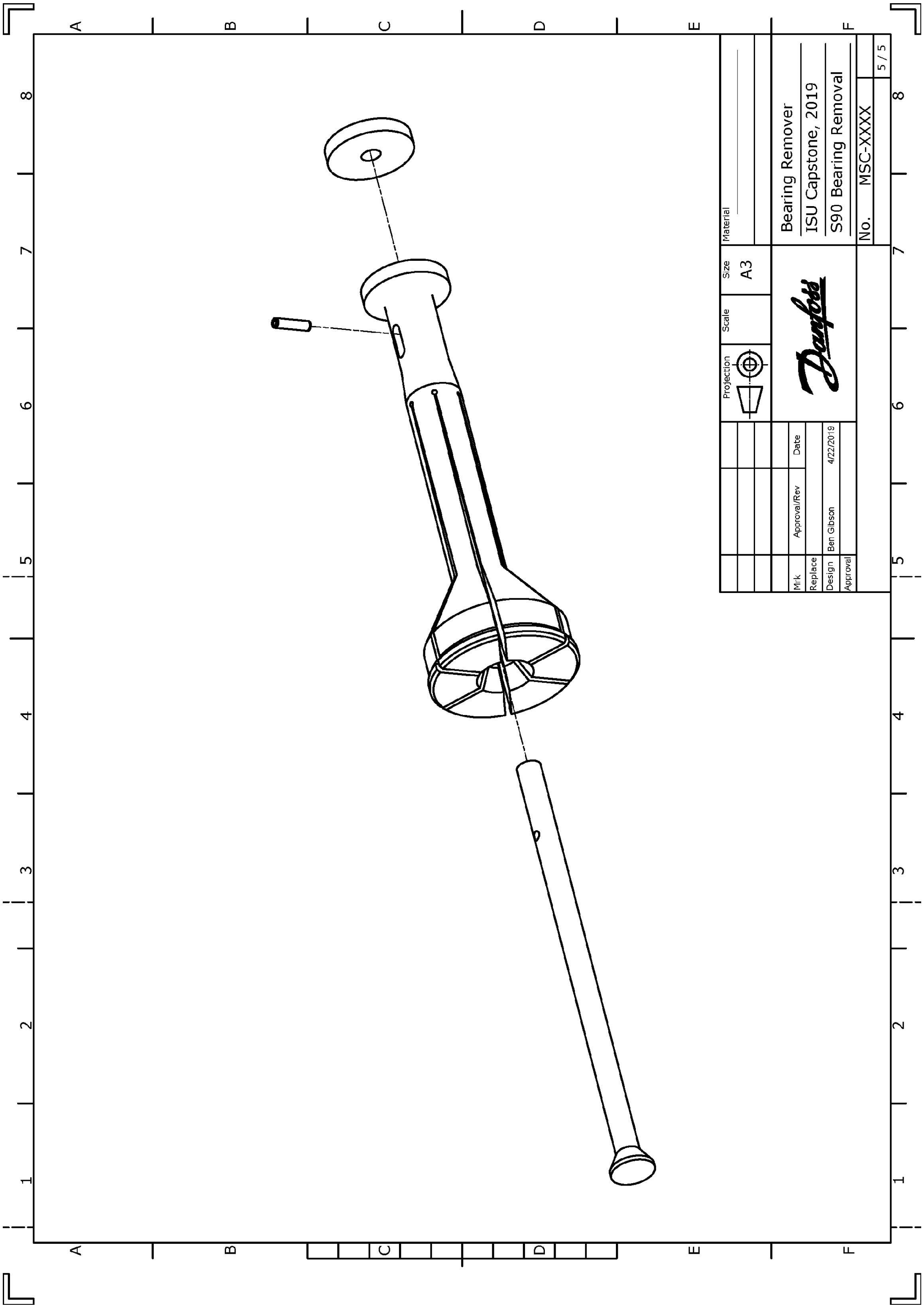
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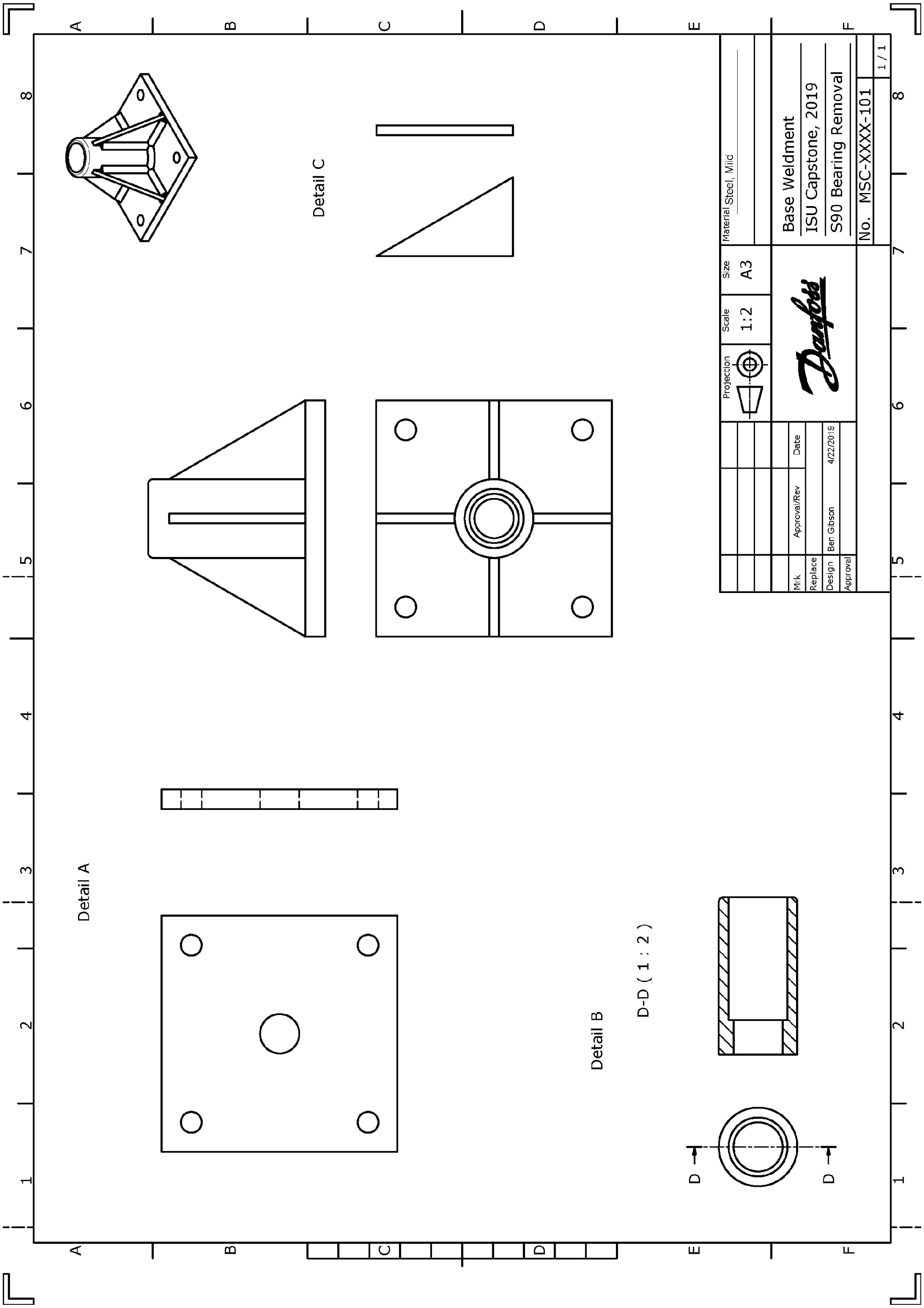
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Detail B
Detail C
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Approval/Rev
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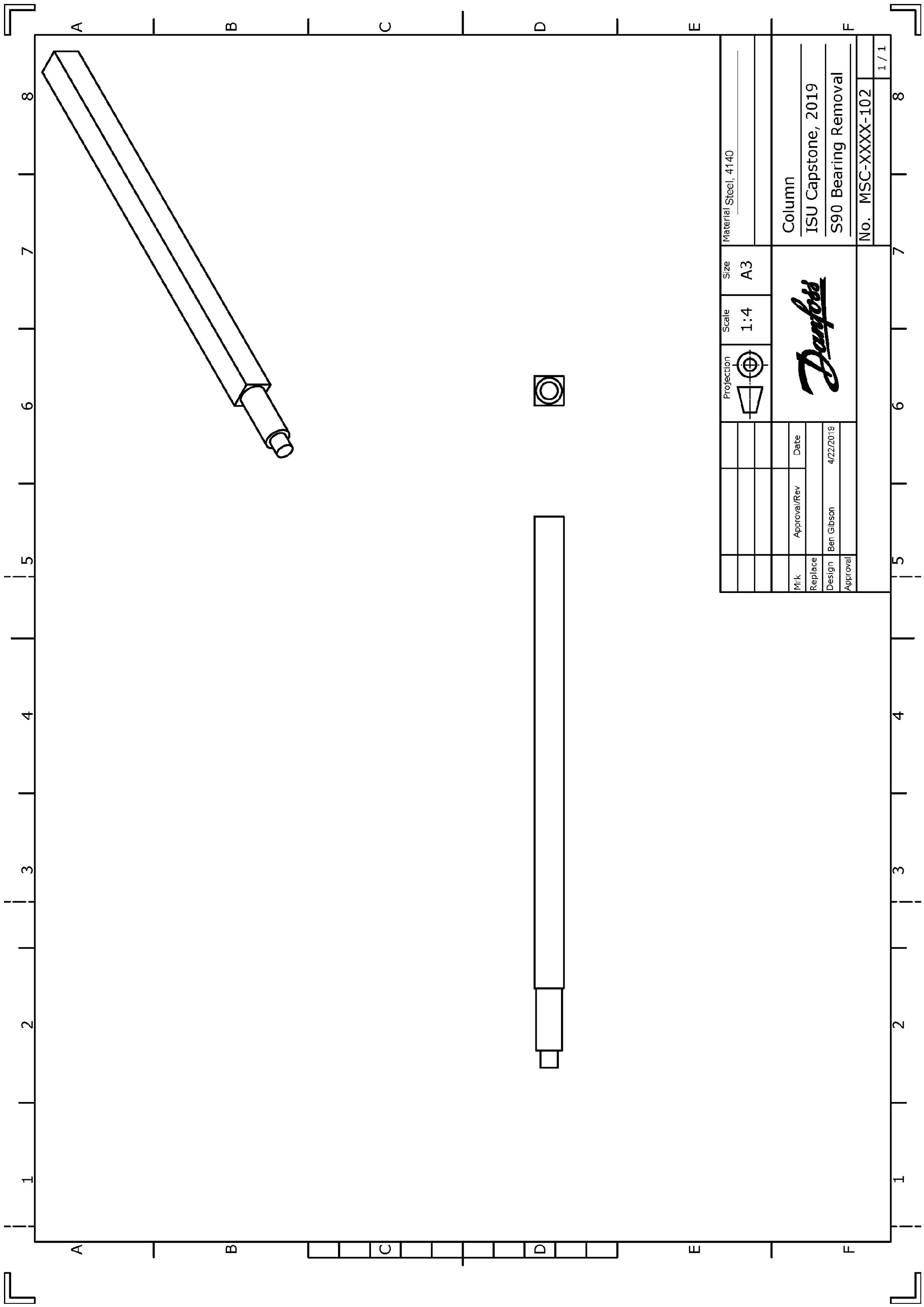
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Danfoss
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Design Ben Gibson
Approval
Approval/Rev
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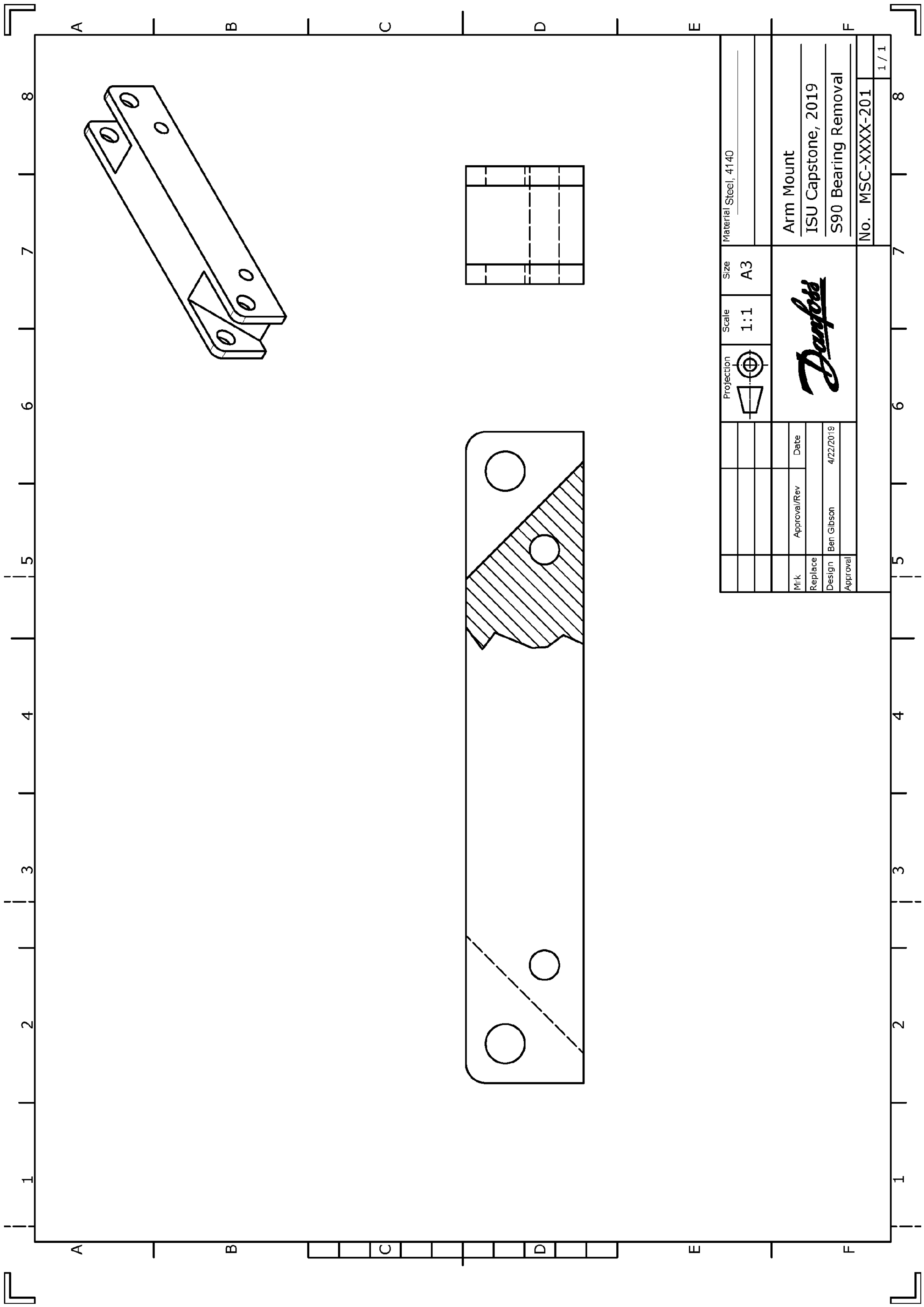
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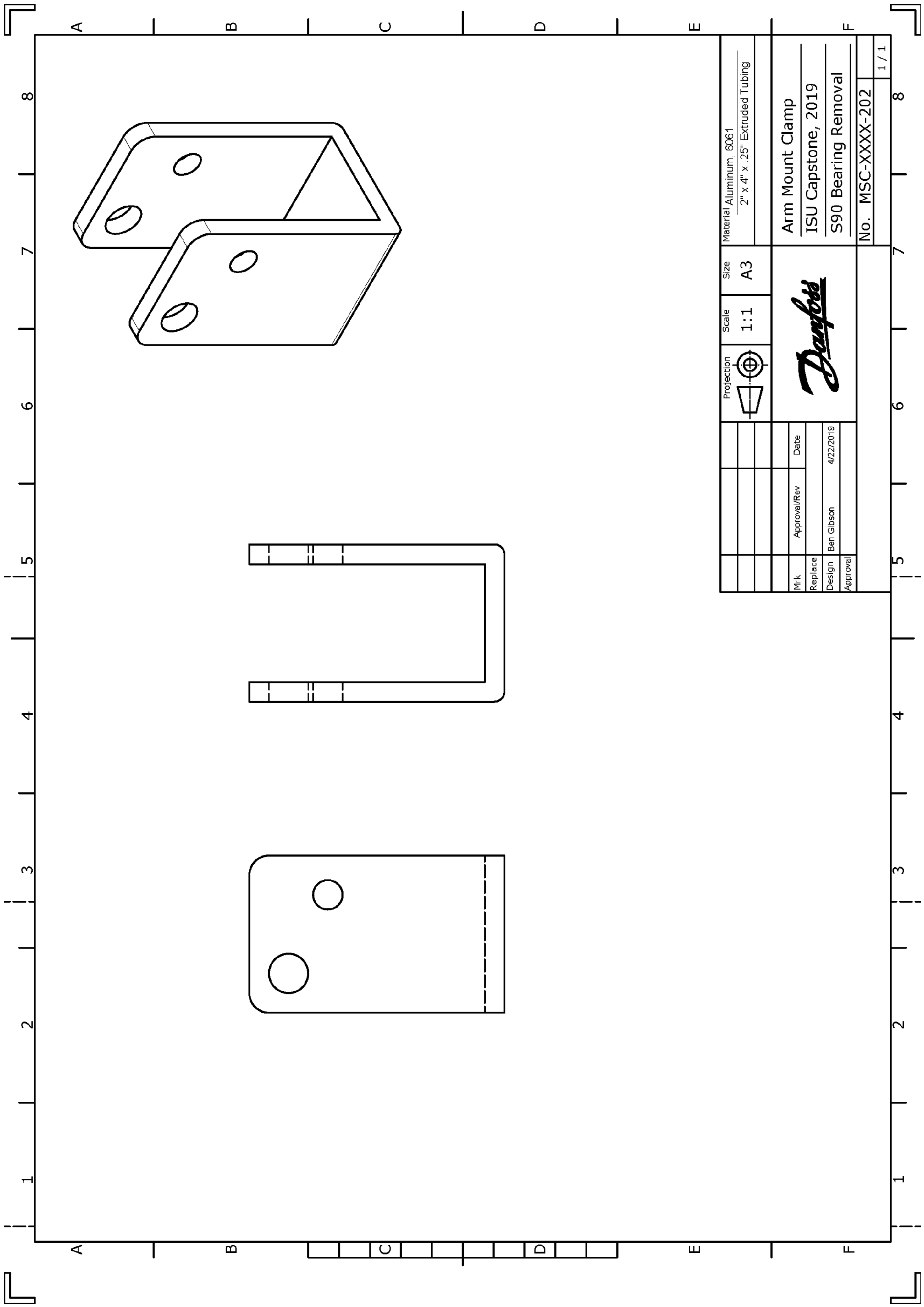
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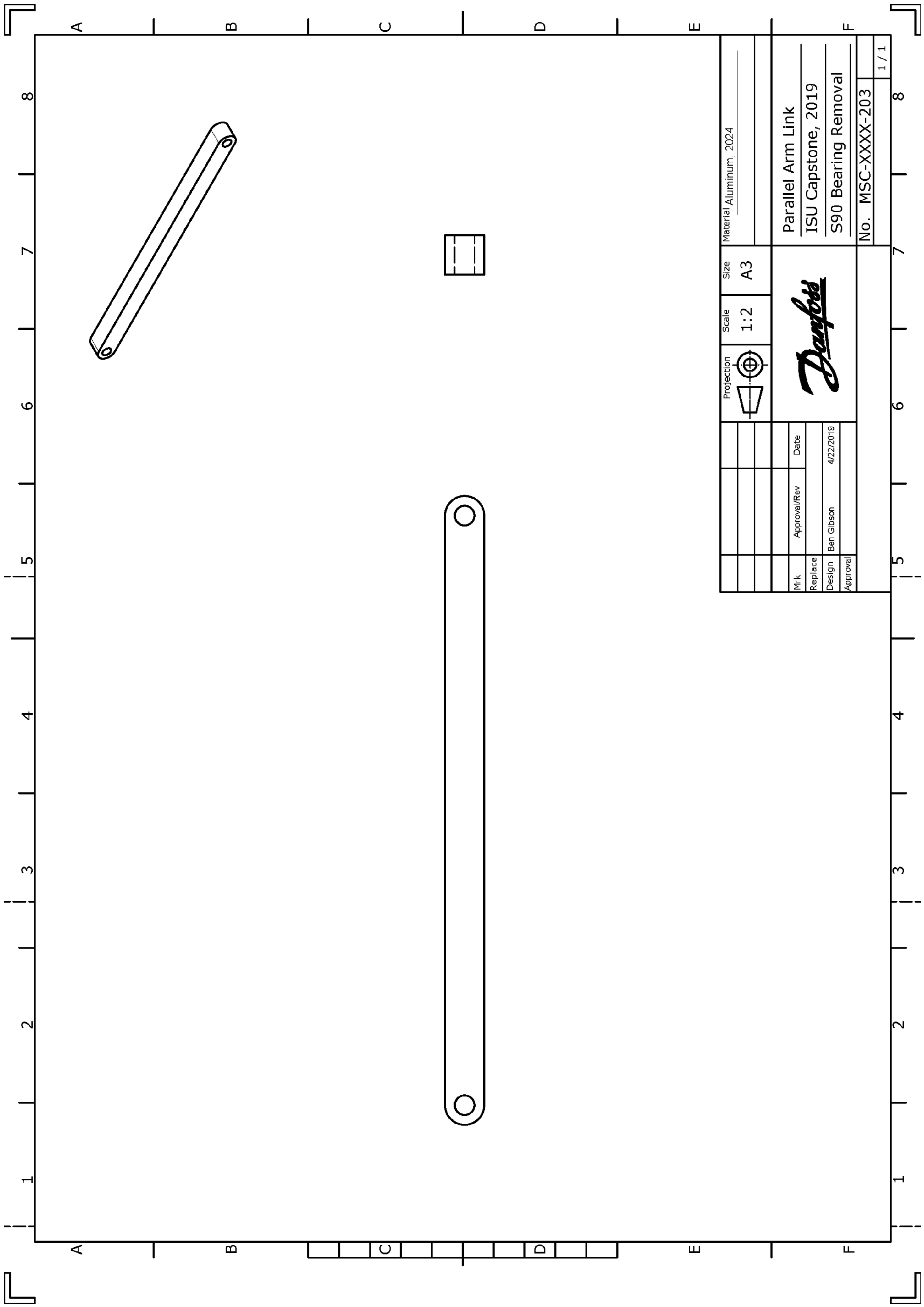
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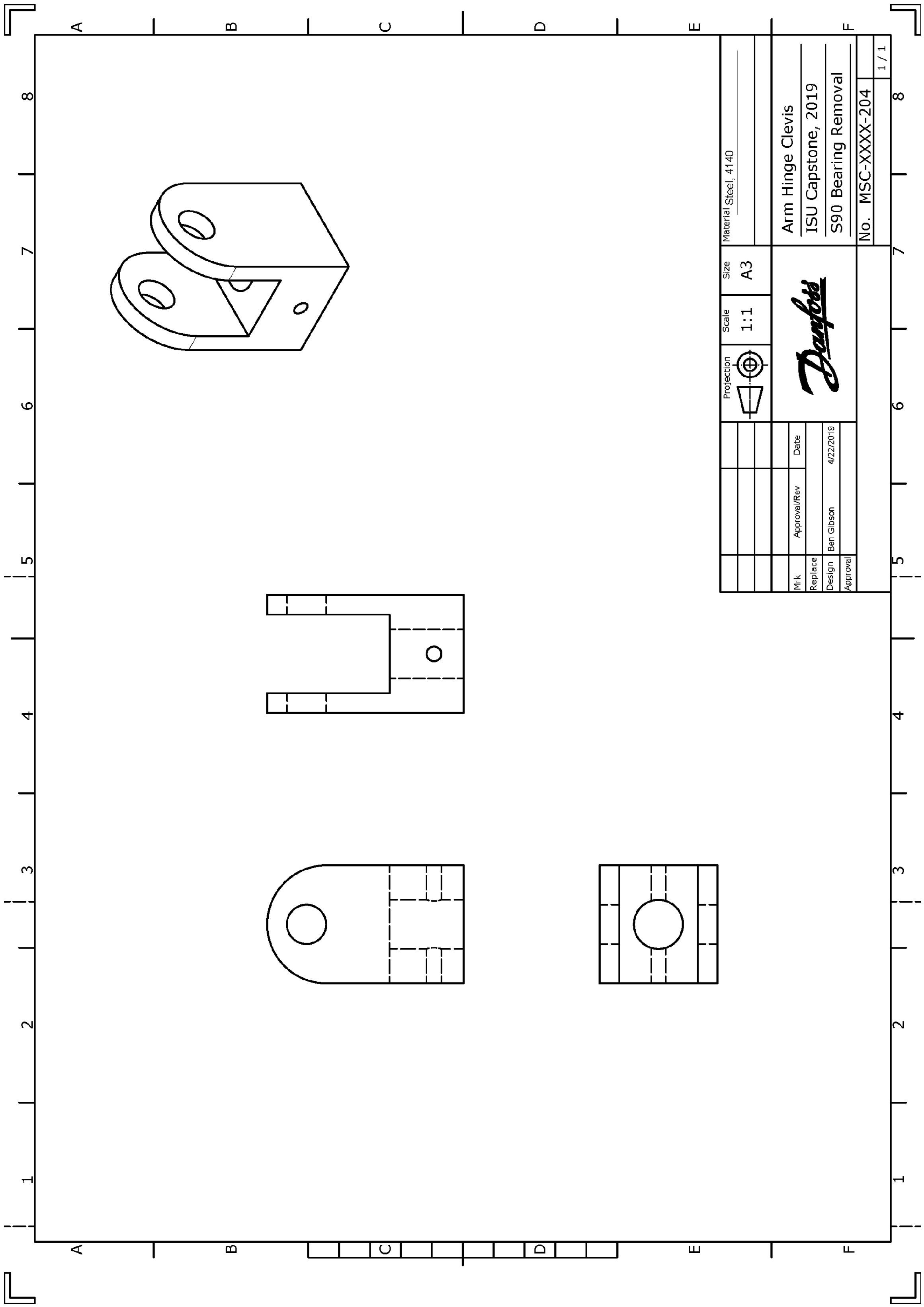
Date 4/22/2019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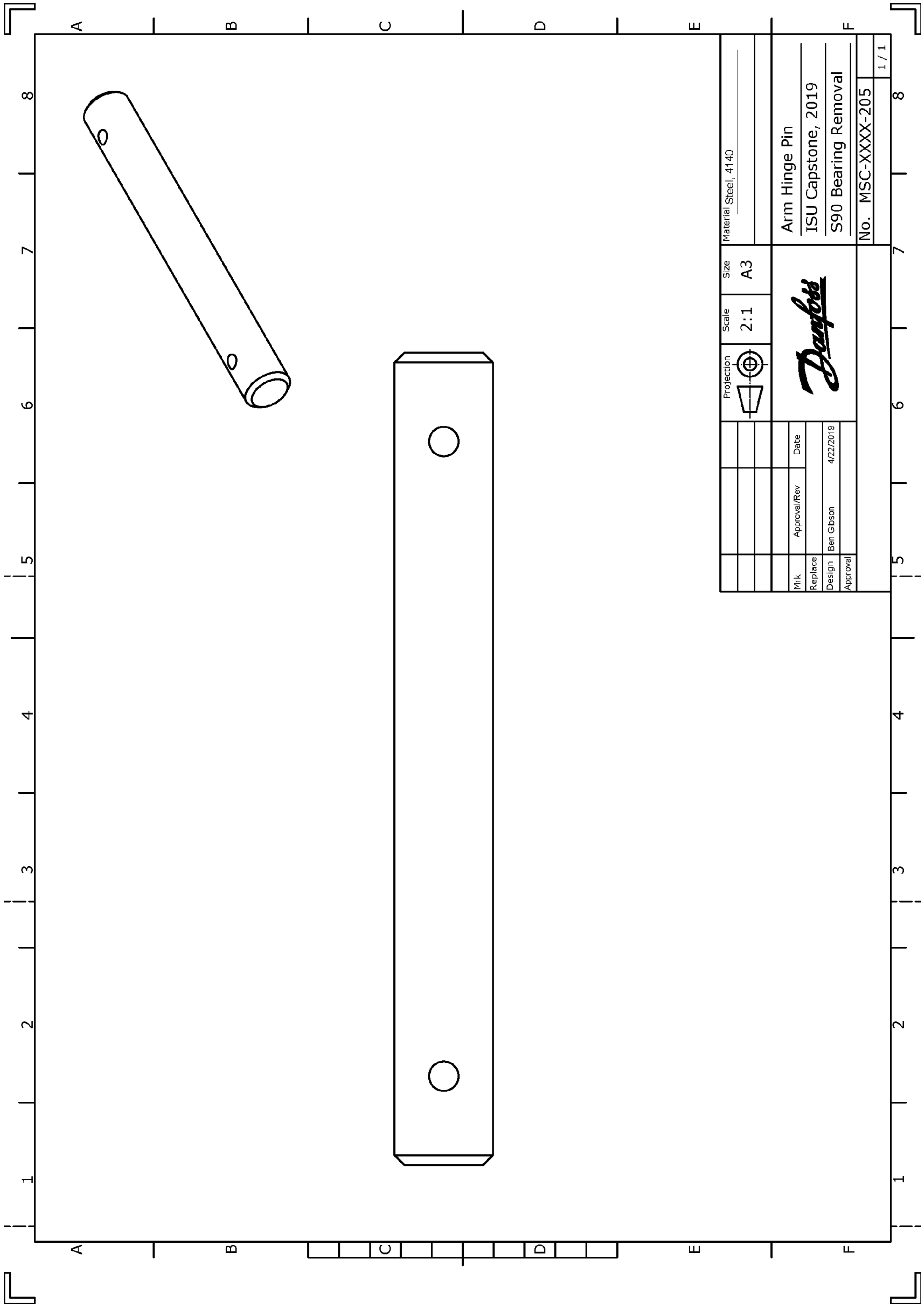
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Design Ben Gibson 4/22/2019
Approval
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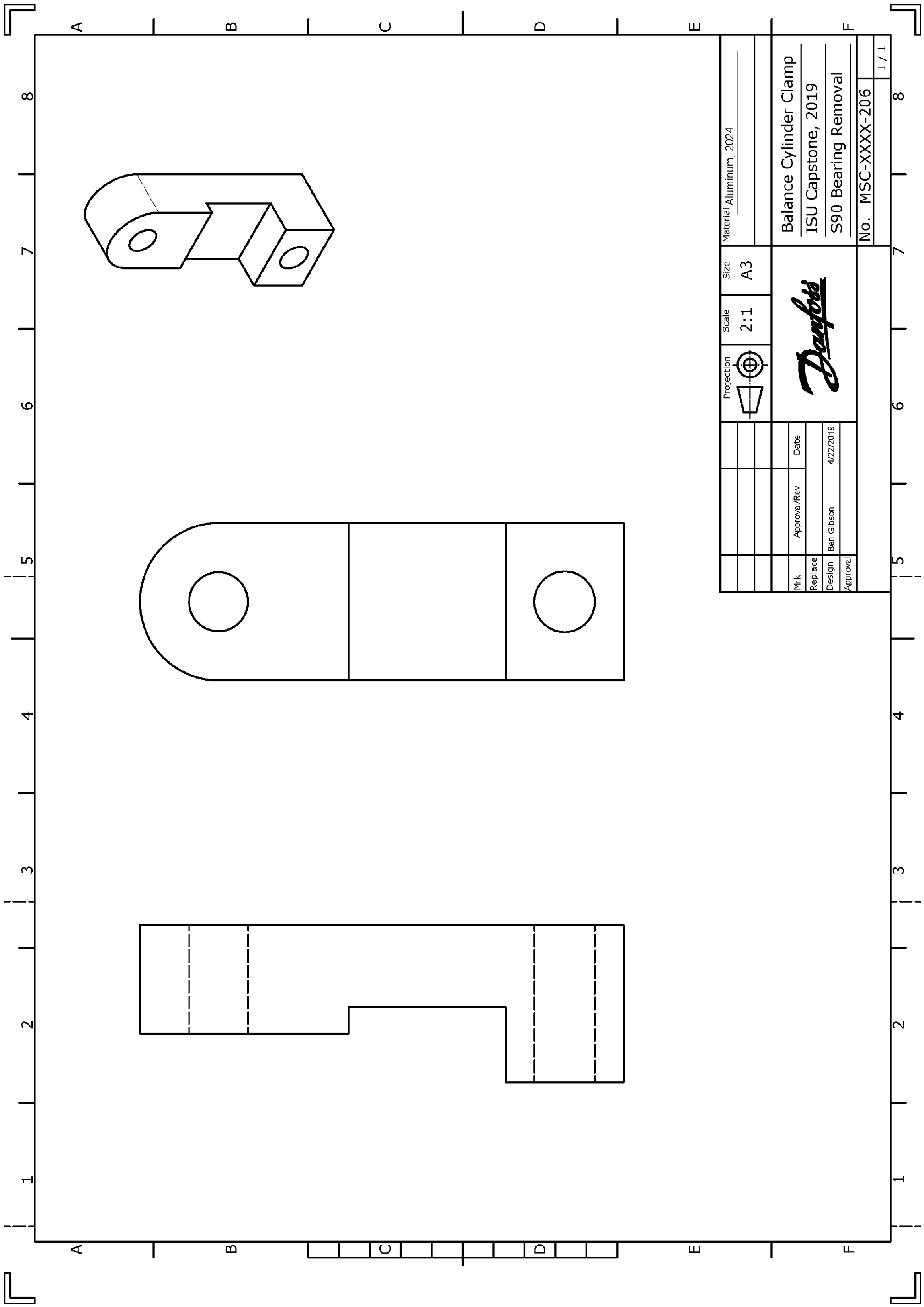
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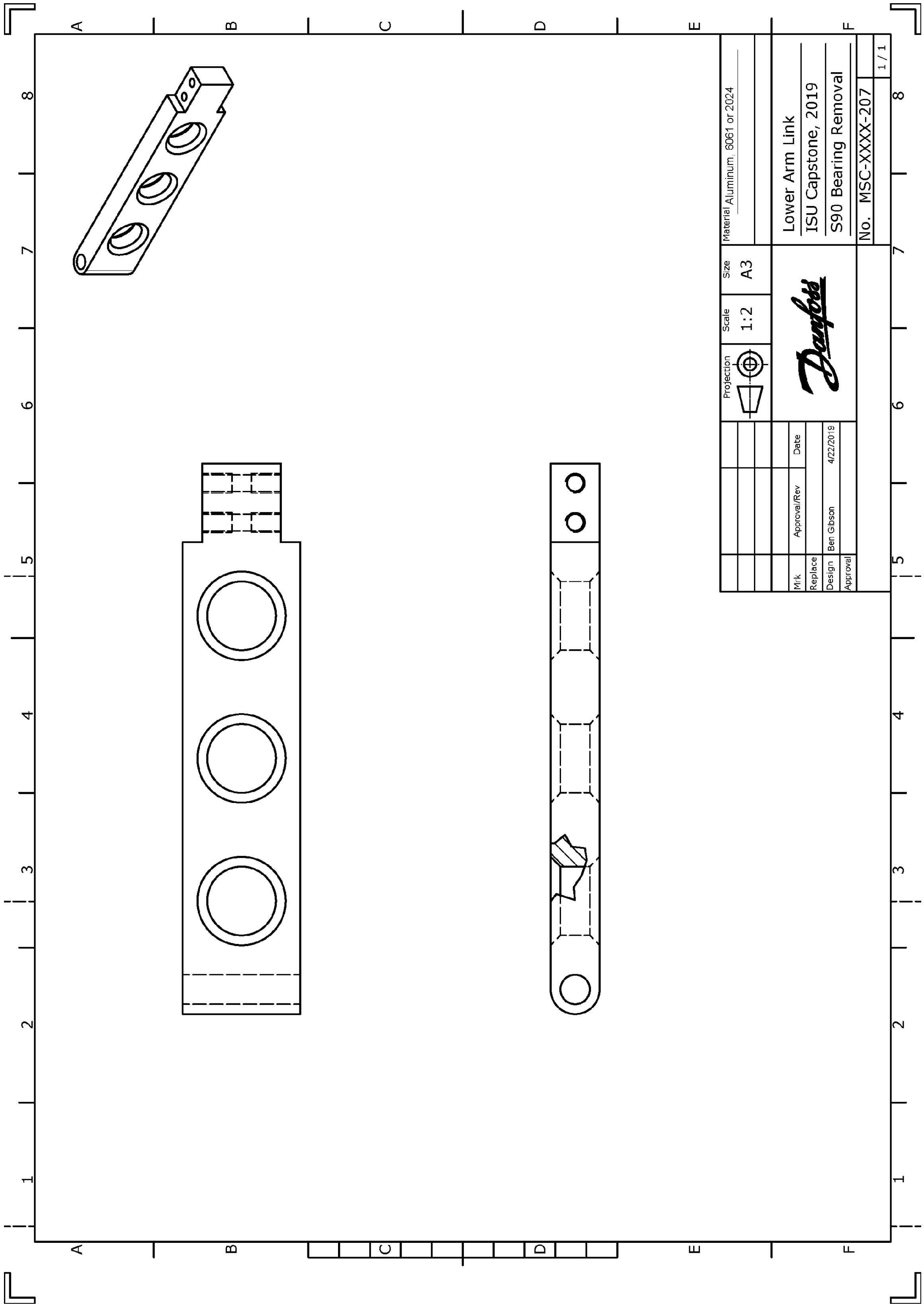
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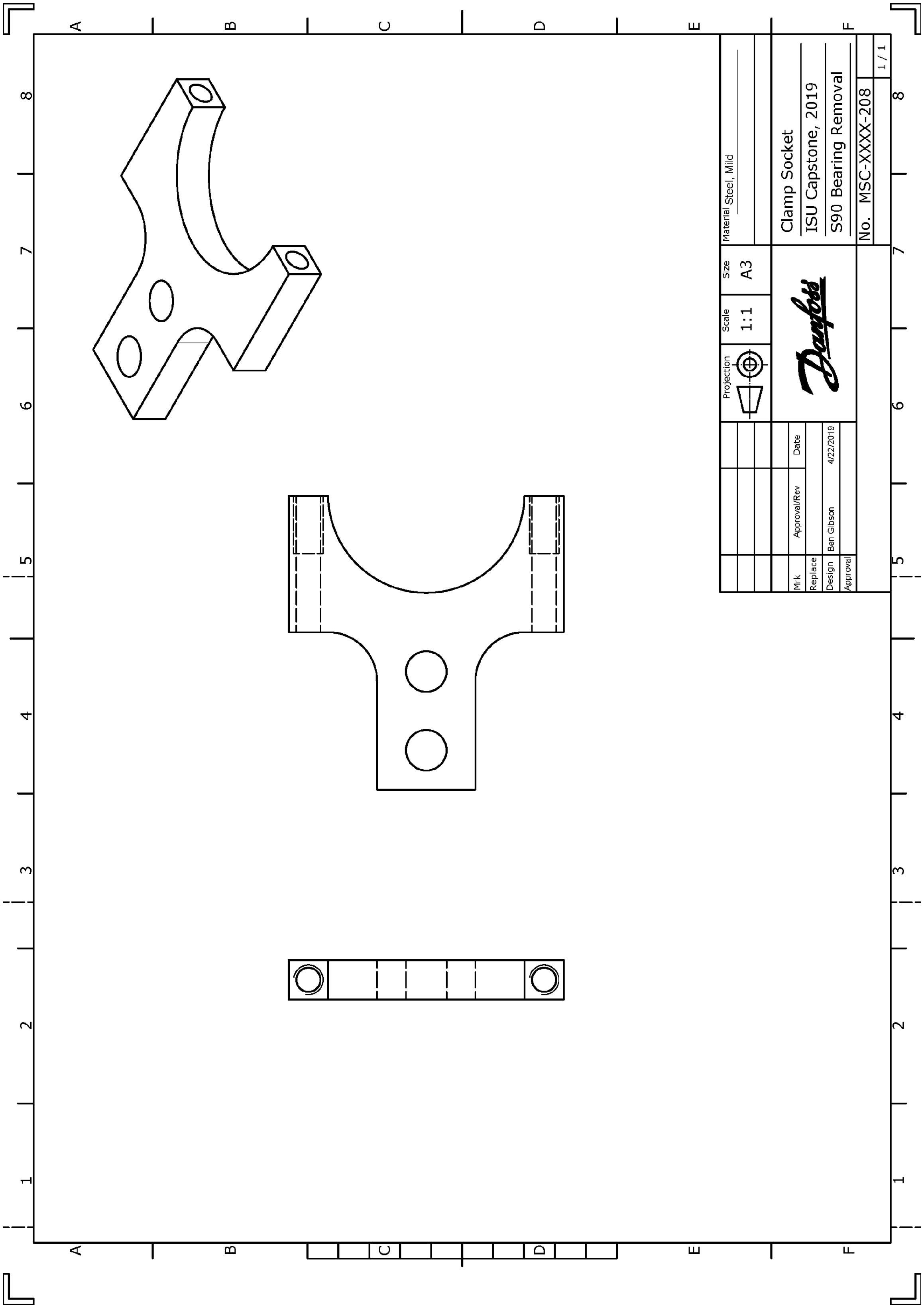
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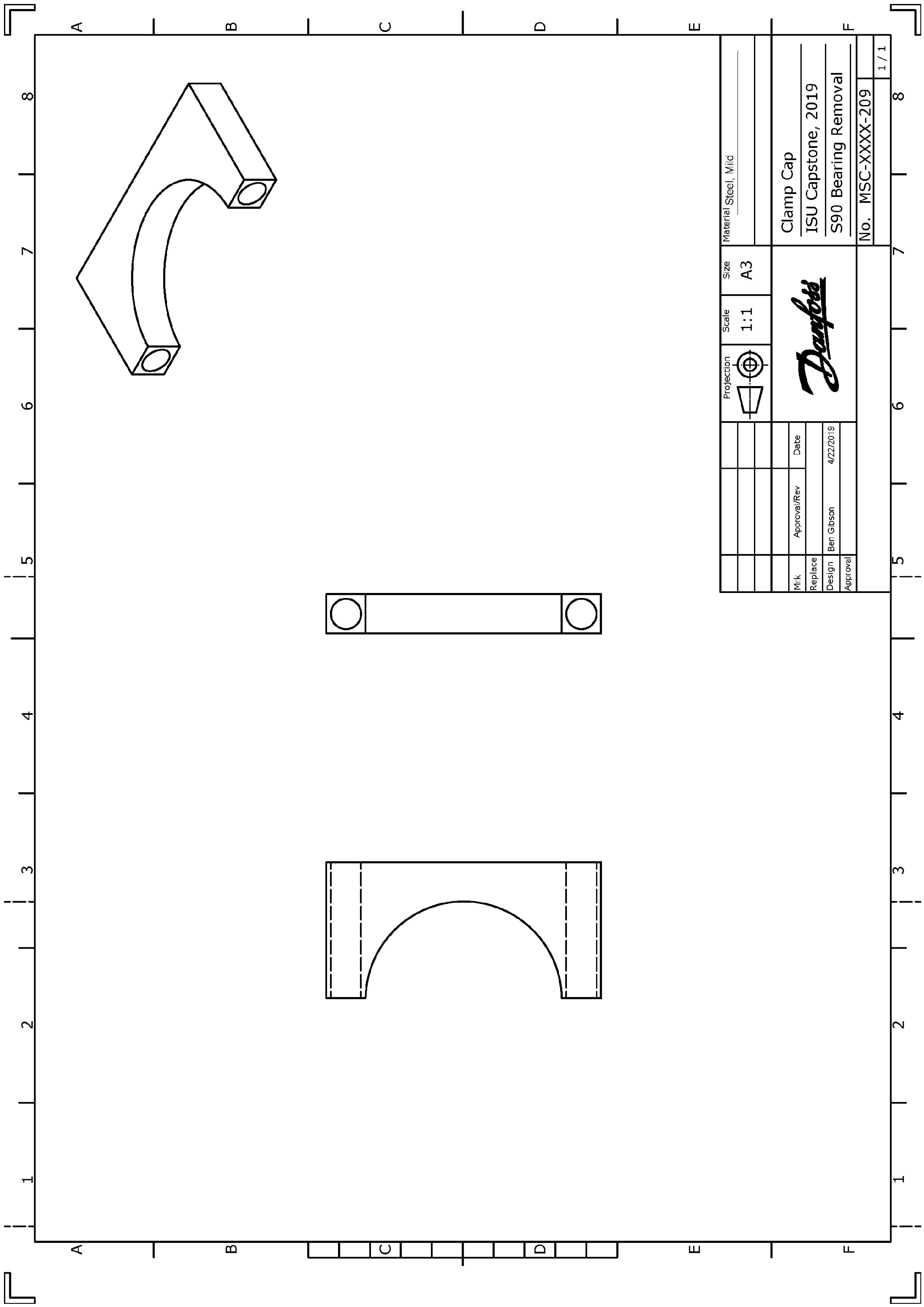
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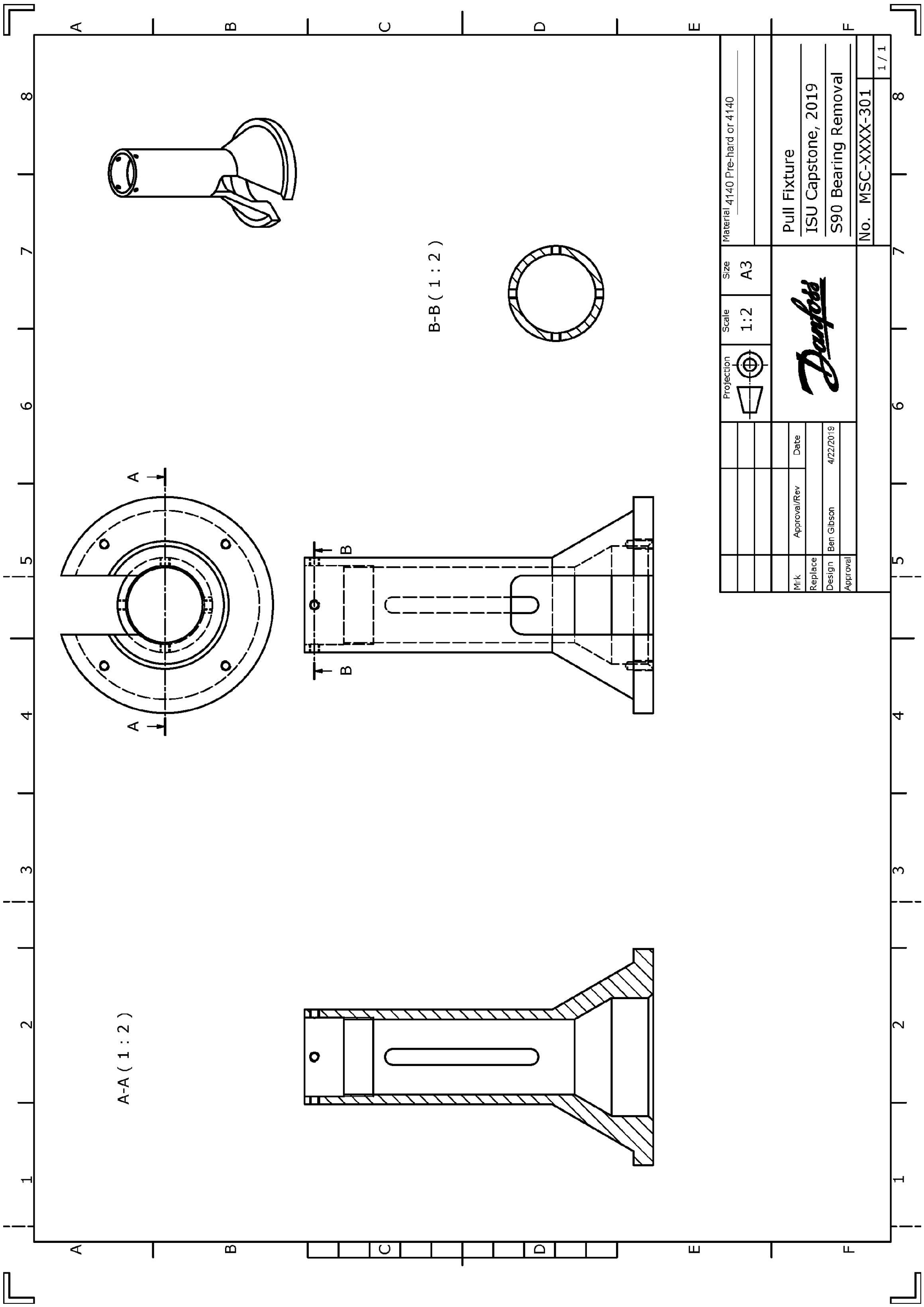
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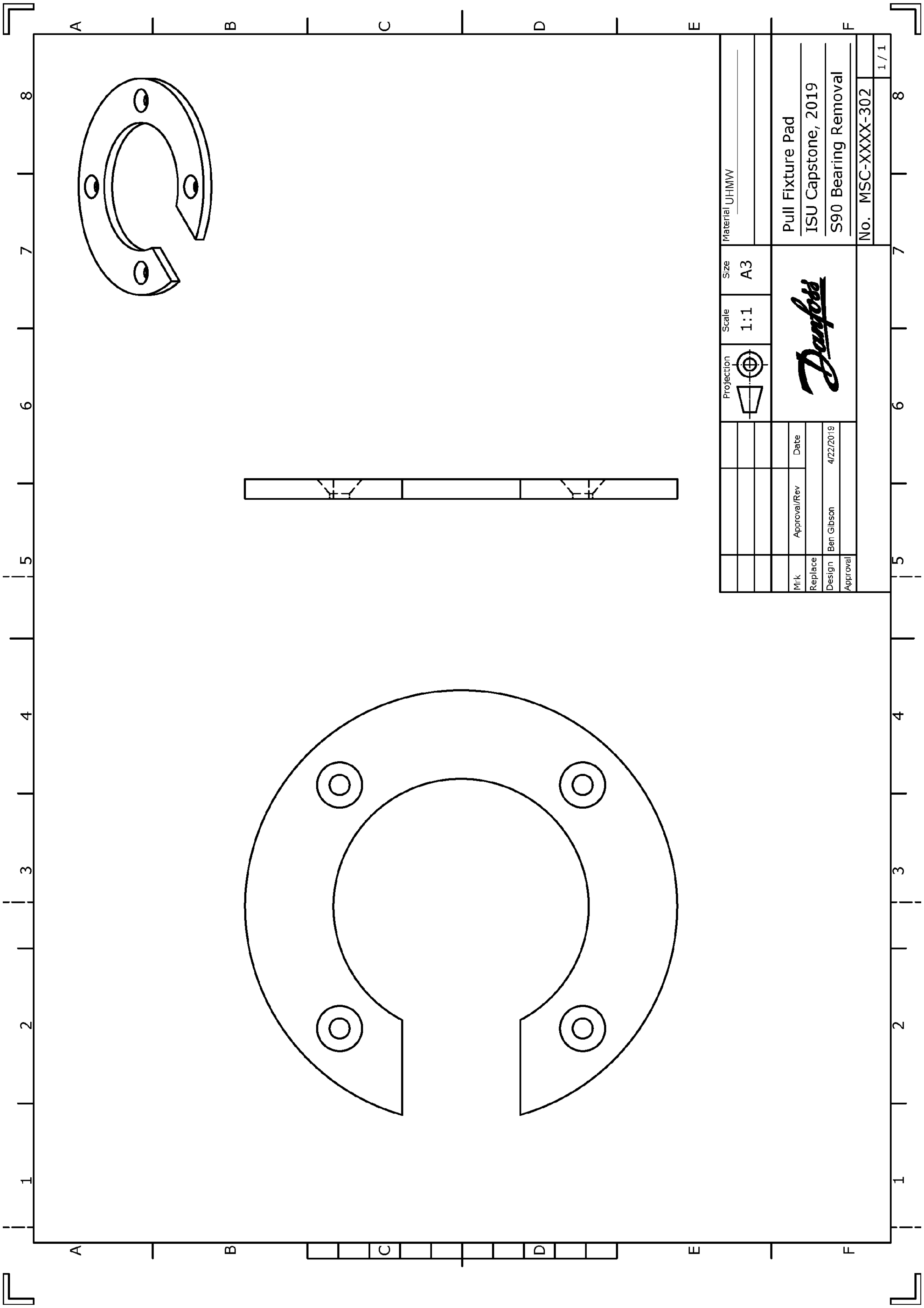
Approval
Approval/Rev
Date 4/22/2019


Pull Fixture Pad
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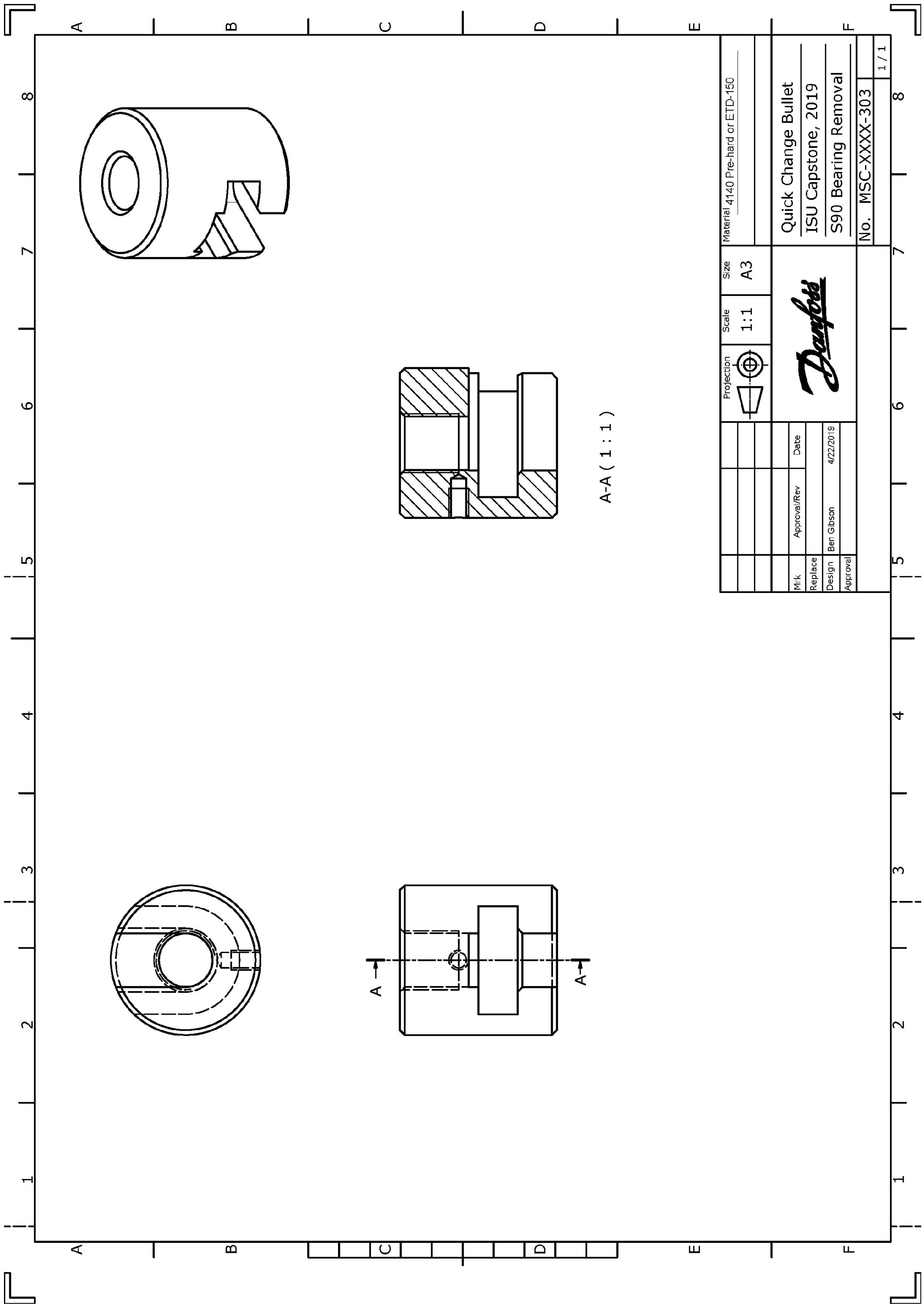
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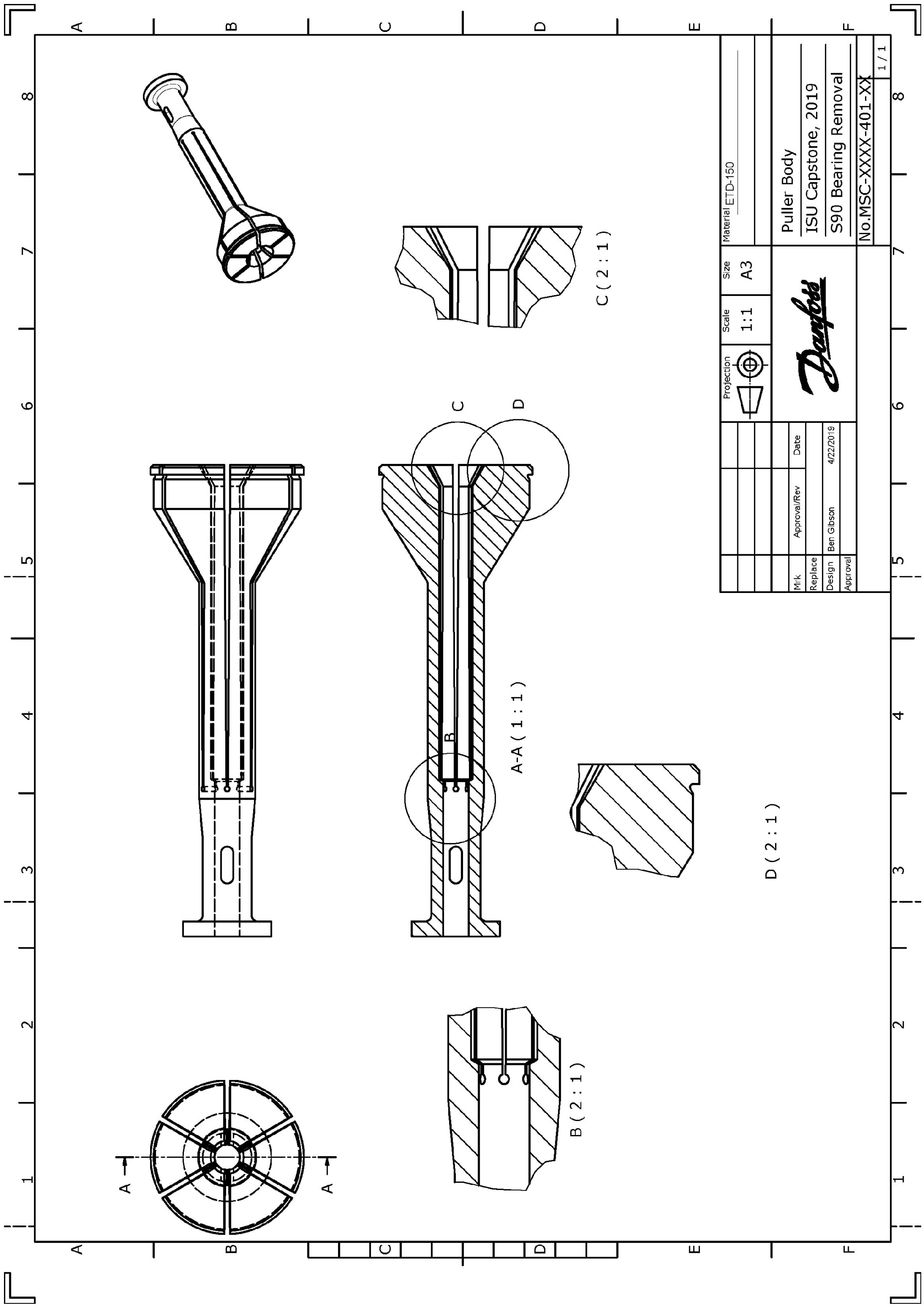
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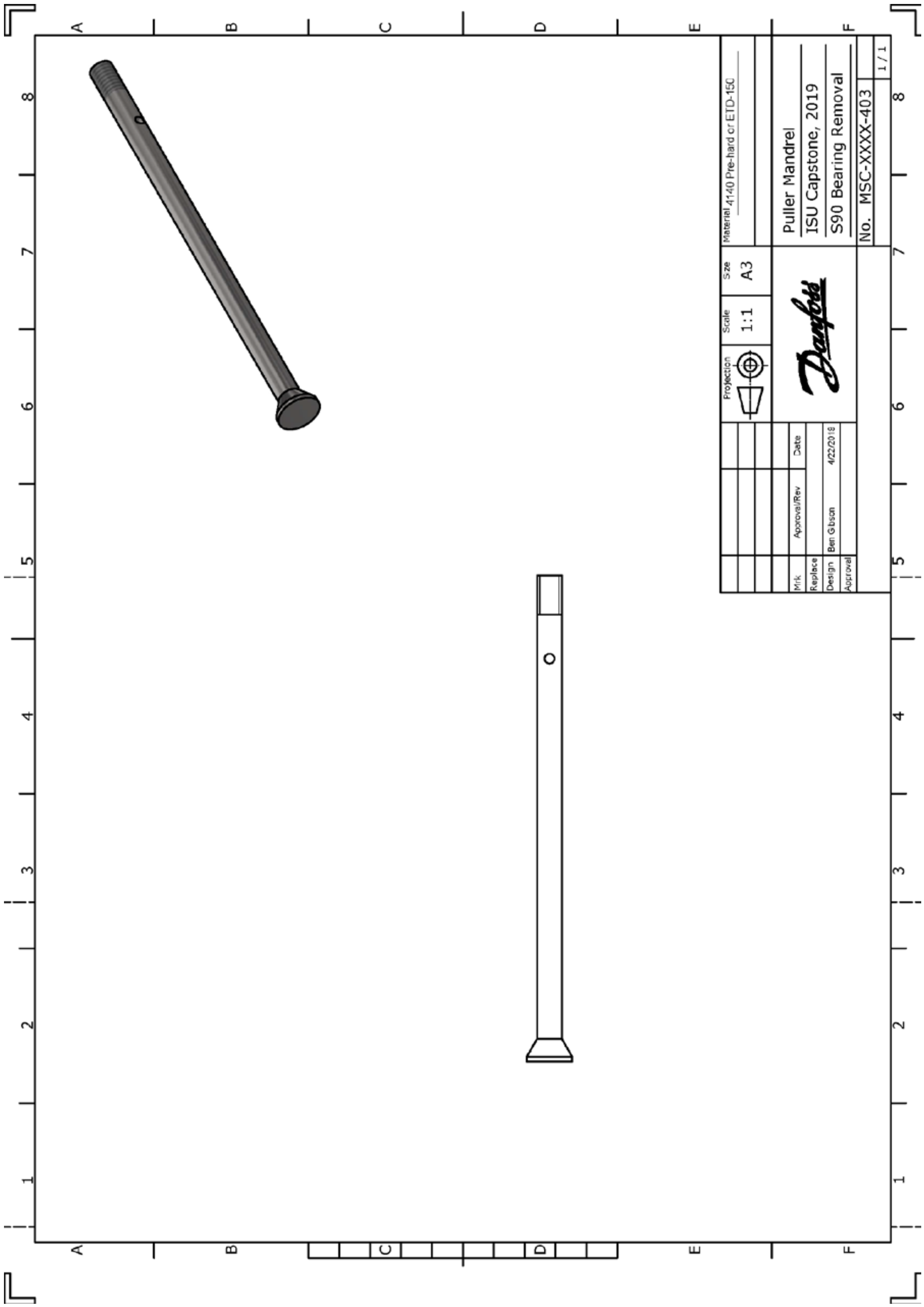
D (2 : 1)
B (2 : 1)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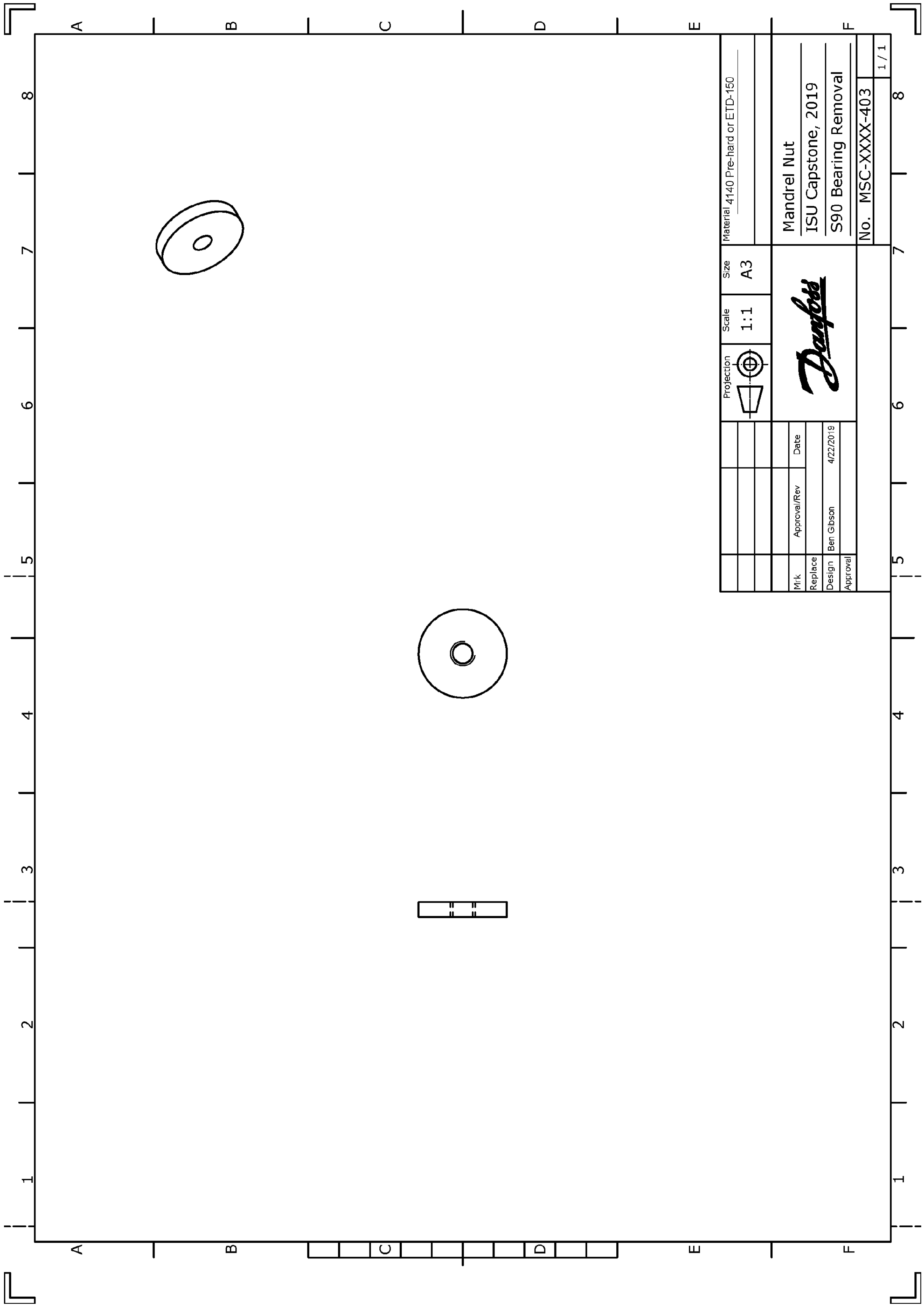
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Mandrel Nut
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S90 Bearing Removal
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1 / 1
Mrk
Replace
Design Ben Gibson
Approval
Approval/Rev
Date
4/22/2019

APPENDIX B – BILL OF MATERIALS

BILL OF MATERIALS WITHHELD FROM PUBLIC RELEASE

APPENDIX C – HYDRAULIC SCHEMATIC

NAME Ben Gibson
CONTRACT S90 Bearing Puller
MODEL MSC-XXXX-500

Danfoss

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DATE 4/23/2019