USER'S MANUAL

MODELS: 5405
5405 FG
5405 EG
5405 ET

Dipole Electromagnet

Model: _____

Serial number: _____

Date sold: _____

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GMW 955 Industrial Road, San Carlos, CA 94070 Tel: (650) 802-8292 Fax: (650) 802-8298
Email: tom@gmw.com Web site: http://www.gmw.com

1. CONTENTS

1. SAFETY

1.1. Symbols Used In This Manual

Important information. This label indicates important information that must be read and understood prior to operation.

Warning relating to the presence of magnetic field.

Warning relating to a trip hazard.

Warning relating to hot surfaces.

Warning relating to the potential for electrical shock.

Warning relating to the potential of injury due to lifting heavy weight.

1.2. Installation, Operation and Service Precautions

During installation or servicing this magnet must be locked out following the Lockout/Tagout procedure defined in section 1.3.

This product is designed for use in accordance with SOP39. Hazardous voltages are present within this product during normal operation. The product should never be operated with any of the covers removed.

When operated at peak direct current of 70A the surface temperature of the coils of the electromagnet can rise as high as 65°C. Care must be taken not to touch the coils for extended periods.

1.3. Lockout/Tagout Procedures

Purpose:

To protect personnel and ensure that machines and equipment are isolated from potentially hazardous electrical energy. Lockout or tagout must occur before employees perform service, maintenance, or renovation. This is important where unexpected start-up could cause personal injury, fire, or equipment damage.

Policy:

All equipment shall be locked out where possible. Where such control is not possible, equipment may be tagged out-of-service. In all instances, equipment shall be made inoperable to protect against possible operation where such operation may cause personal injury or damage. Employees must not attempt to operate any switch or source of energy which is locked out or tagged out.

Procedures:

1. **When working on systems which could accidentally be activated, the system shall be locked out or tagged out by use of a safety lockout device and padlock. In addition, a tag shall be used to identify the purpose of the shutdown, the employee involved, the date the unit was removed from service, and when the system may operate again.**

2. **If more than one source of energy is present, all such sources must be locked out or tagged out. Special procedures must be followed to ensure that the equipment is disconnected from an energy management system or emergency generator system that may start or energize the equipment.**

3. **A lockout is required on all systems where possible. A tagout is an acceptable means of protection on systems which are less hazardous. An example of less hazardous is a device, if started accidentally, would not cause personal injury.**

4. **If more than one person is involved in the repair, each person shall install a lock and or tag to the equipment energy source. An employee may not use the tag or lock of another employee.**

5. **After servicing, renovation, or maintenance is complete, the area must be checked for tools, parts, removed guards, and assurance that no personnel are in the danger zone. Then the lockout or tagout will be removed by the same employee who initially locked it out so energy may be restored to the equipment.**

6. **If the employee who locked out or tagged out the equipment is unavailable, the supervisor may remove the lock or tag if the following conditions are met:**
    1. **Verification that the employee who applied the device has left for the duration of the shift and is not at the job site.**
    2. **Made reasonable efforts to reach the employee.**
    3. **Inform the employee that the lock or tag has been removed and the system is no longer de-energized, before the employee resumes work.**

7. **Employee's using lockout/tagout devices shall have training about this program, and shall have annual retraining to ensure that the employee understands and follows this program. The training and retraining shall be documented with the training records maintained by the training coordinator.**

8. **Outside contractors are required to follow this policy or provide a similar policy that is in compliance with Occupational Safety and Health Administration (OSHA) Standard 1910.147. Under no circumstances are outside contractors authorized to remove a lockout/tagout device nor are they allowed to energize a locked out/tagged out system.**

Lockout/Tagout Procedures Checklist:

The following steps must be followed in sequence to properly lockout/tagout and re-establish energy:

I. Understand the hazard:

Electrical

Electrical Shock and or burn could result from contact with the exposed conductors line voltage or high voltage equipment. Flying parts or fire could result if this circuit were shorted. Electricity should be controlled at the circuit breaker, main switch, or fuse box.

Mechanical

Equipment or machinery can inflict tissue or skeletal injury through crushing, laceration or impalement. This can be controlled through the main electrical switch, plug, circuit breaker or anti-motion pin.

Thermal

Can cause burns or fires. It can be controlled by the main electrical switch, electrical plug control, electrical circuit breaker, electrical fuse box, steam valve, fluid line valve or shielding.

II. Shutdown:

Know what type of energy the machine uses.
Identify its potential hazards.
Find the switches or other devices that control energy and need to be locked out.
Let employees know that you will be locking or tagging out the equipment and why.
Turn off the machine or equipment.

III. Isolate the source of energy

Electrical

- **Locate the main switch box or circuit breaker.**
- **Open the breaker, open the switch or remove the plug.**

- **Attach a lockout enabling device if the circuit cannot otherwise accommodate a padlock.**
- **Place plug in a plug lock box.**

Mechanical/Storage Potential Energy

- **Lockout enabling device.**
- **Secure the energy controlling lockout by attaching a personal lock and completed tag to the lockout enabling device. If more than one person will be performing the work, each must apply their own lock to a multiple lock device.**
- **Release all stored energy.**
- **If there is a heat exposure, allow to cool.**

Release from Lockout/Tagout

1. **Inspect the surrounding area following completion of work for loose tools, parts, correct valve settings, system integrity, exposed conductors.**
2. **Check that all machine guards are in place and reconnected if applicable.**
3. **Notify others in the area that the equipment is about to be made operational and returned to service.**
4. **Remove personal lock, tag, and lockout enabling device. This step must be performed by the same person who applied the tag and lock.**

Lockout/Tagout Training

The lockout/tagout program is designed to train employees on disabling powered equipment from their power sources before beginning any servicing or maintenance work. Lockout/tagout training is required for all employees who may possibly need to lockout and tagout equipment.

Employees will receive annual training in the following areas:

1. **Recognition of applicable hazardous energy sources.**
2. **Methods and Means necessary for energy isolation and control.**
3. **Restrictions and limitations of lockouts.**

2. SPECIFICATIONS

2.1. General Specifications

The 5405 Series electromagnets feature a C-frame yoke, identical coils and accommodate a series of interchangeable poles which can be ordered additionally. The series offers the following configurations:

5405: Standard configuration electromagnet with adjustable pole gap.
5405 FG: Fixed Gap; standard configuration with poles set to a fixed spacing.
5405 EG: Extended Gap; widened yoke to increase pole spacing.
5405 ET: Extended Throat; heightened yoke to allow access to central region of larger samples.

Model			5405	5405 FG	5405 EG	5405 ET
Magnet Field at (X, Y, Z = 0, 0, 0mm)						
Pole Spacing 20mm, Series/Parallel Connection						
38mm Pole (For Comparison)						
Max triangle wave current $120A_{peak}$, 6.0kW			$B_z = \pm 2.18T$		FUTURE DEVELOPMENT	FUTURE DEVELOPMENT
Max sinusoidal wave current $100A_{peak}$, 6.0kW			$B_z = \pm 2.10T$			
Max DC current 70A, 6.0kW			$B_z = \pm 1.95T$			
Coils (series connection)						
Coil Resistance		Series	3.48 Ω @ 20°C		4.13 Ω @ 70°C	
		Parallel	0.22 Ω @ 20°C		0.26 Ω @ 70°C	
		Series / Parallel	0.87 Ω @ 20°C		1.03 Ω @ 70°C	
Max Power (water cooled @ 8 lpm)			70A/86V (6.0kW)			
Max Power (air coolied in 18°C ambient)			TBC			
			Low Field		High Field	
Self Inductance		Series	1660 mH		400 mH	
		Parallel	105 mH		25 mH	
		Series / Parallel	420 mH		100 mH	
Water Cooling (18°C)			8 liters/min (2.1 US GPM), < 4.0 bar (60 psid)			
			Coils are cooled in parallel with 4 lpm flowing through each.			
Over-temperature Interlock			Selco 802L-070 thermostat			
			Contact rating 120VAC, 1.0A. Closed below 70°C			
Dimensions		W	604mm (23.8")	FUTURE DEVELOPMENT	FUTURE DEVELOPMENT	604mm (23.8")
		D	315mm (12.4")			
		H	356mm (14.0")			FUTURE DEVELOPMENT
Drawing No.			11907-0450-0_S1	FUTURE DEVELOPMENT	FUTURE DEVELOPMENT	
Mass			153 kg (337 lb)			
Model			5405	5405 FG	5405 EG	5405 ET

CAUTION - The value of maximum coil resistance given should not be exceeded. At this resistance the coils are at maximum safe temperature for continuous operation.

2.2. 5405 Series Electrical and Water Connections

DC Current

The 5405 Series electromagnets are shipped with the power and water connections not connected. The connections for the power supplies are made according to the power supply being used. The 5405 Series electromagnets are shipped with the coils connected in series/parallel configuration requiring connection to a power supply for installation. Refer to section 14 for connection details.

Ground

The coil cooling plates and magnet body are all earthed through the power supply earth.

Interlocks (refer Section 8)

The 5405 series are fitted with four thermostats, Selco part no 802L-070. Two thermostats are fitted to each coil, underneath the terminal covers. The thermostat is normally closed, opening when the coil heatsink temperature exceeds 70°C, ± 5°C.

Water

Clean, cool (16°C - 20°C) water at 8.0 lpm at < 4.0 bar (60 psid) should be used to cool the electromagnet. This can be provided by house water supply or from a recirculating chiller. An appropriate recirculating chiller is the TF90 from Thermofisher for 900W of time-averaged power dissipation or the TF150 for 1500W of time-averaged dissipated power. Neither are suitable for long term operation at peak current. If house water supply is used, an in-line 50 micron water filter should be used for the supply line to the magnet. Also, 10m of hose is provided to give two 5m lengths for connection between the magnet and the recirculating chiller (if ordered), brass fittings on the chiller are already provided. Note that 4 hose clamps have also been provided for fitting these water hoses.

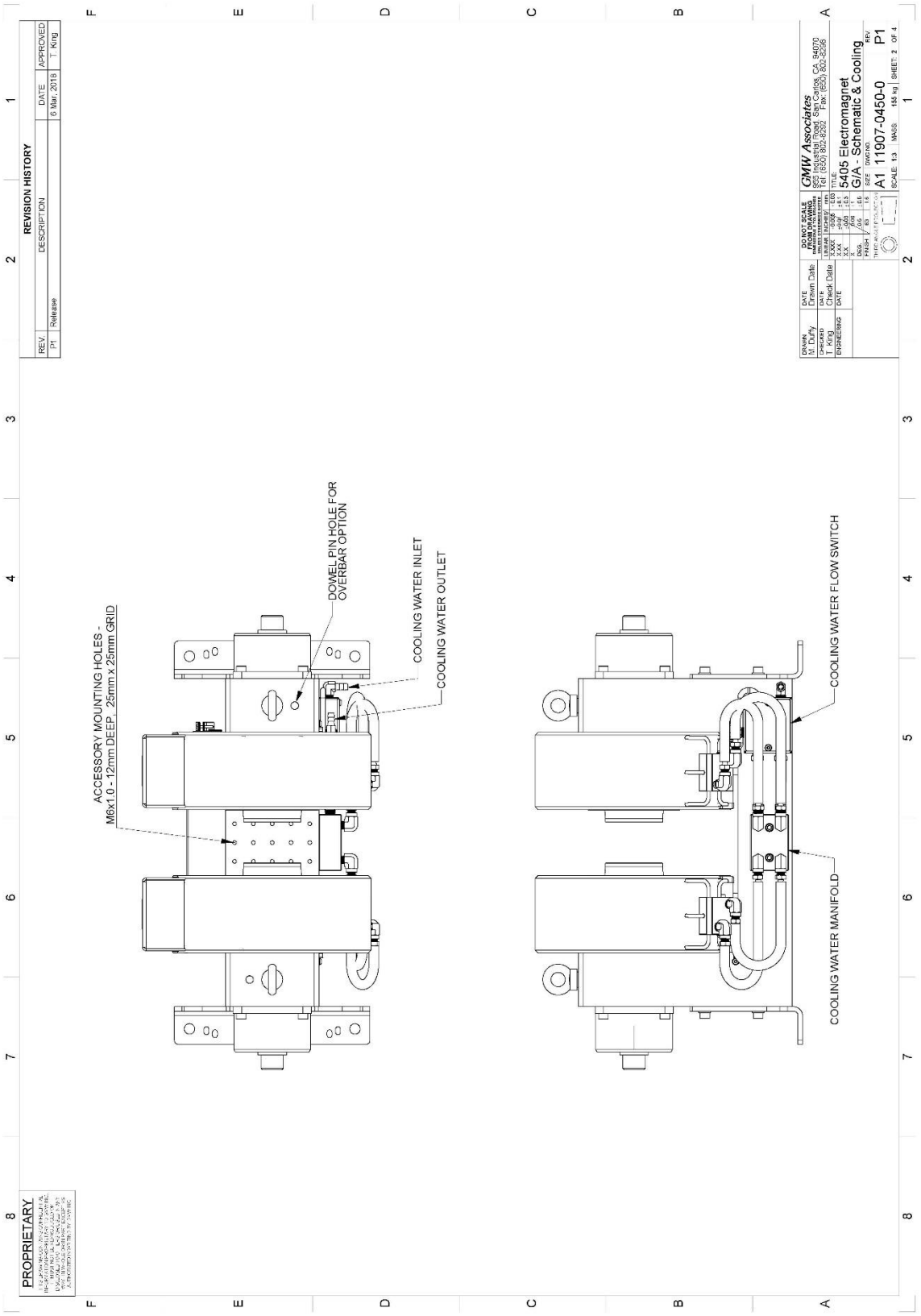
Outlet: 1/8 inch NPT hose barb
Inlet: 1/8 inch NPT hose barb

Air

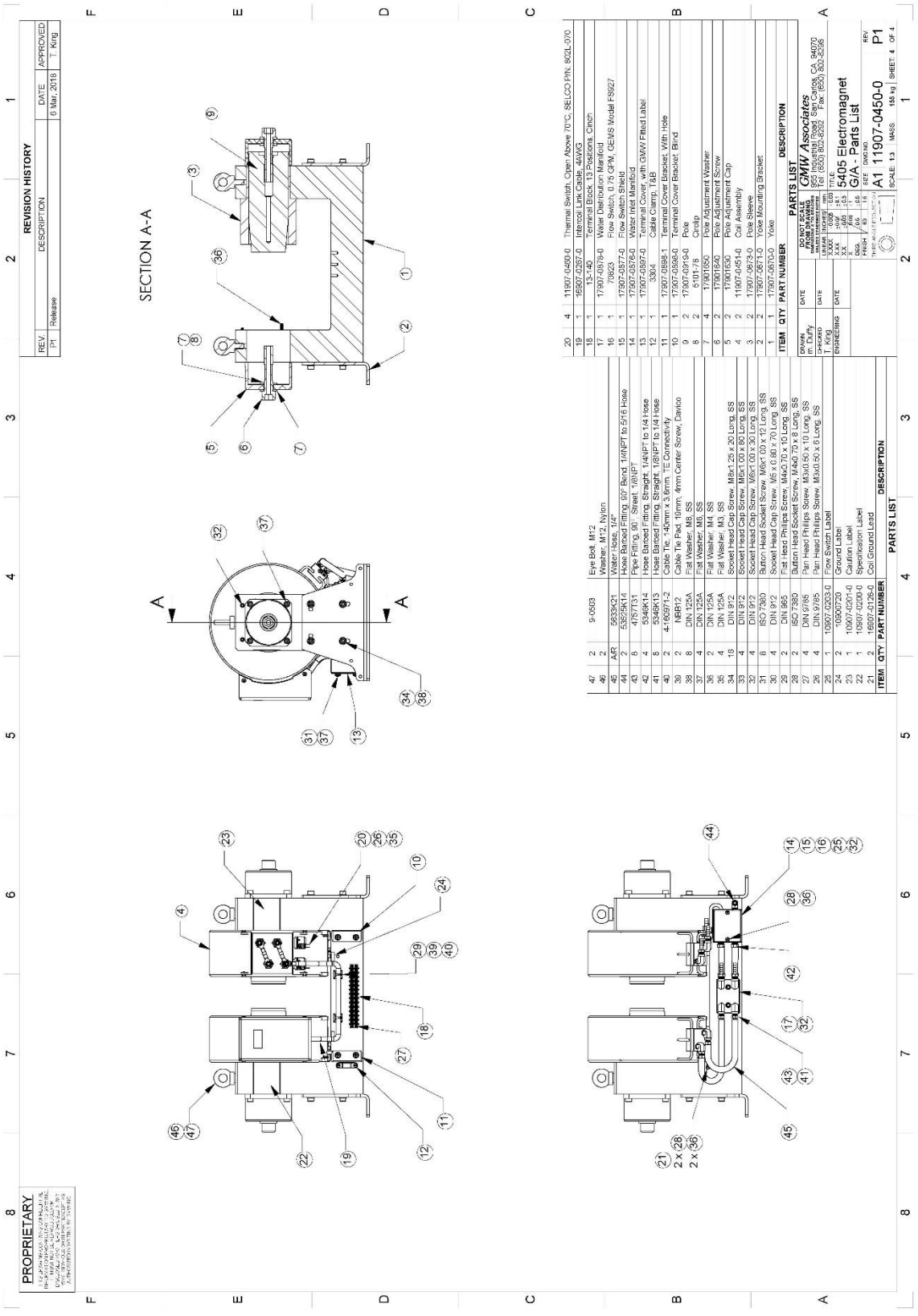
In general air cooling does not require any connections. However, if it is intended to cool the magnet by force cooling through the water cooling manifold then the following applies. The requirements of air cooling connections are not as stringent as for water cooling as there is no impact in the event of small leaks. However, it is recommended that the same connection procedure is followed as per water. It is important for the long term operation of the magnet that CDA is used for forced air cooling.

Ensure that the high current connections are tight. Loose connections may lead to oxidation and overheating. The field stability may be degraded and the current terminations damaged.

2.3. Drawing 11907-0450-0_S2_P1_5405_General_Assembly



2.4. Drawing 11907-0450-0_S4_P1_5405_G/A_Parts_List



3. WARNINGS

REFER TO WARNINGS BELOW BEFORE OPERATING ELECTROMAGNET

1 Personnel Safety

The 5405 Series produce a low level of fringe field. In operation the magnet fringing field can be in excess of 0.5mT (5G). This can cause malfunctioning of heart pacemakers and other medical implants. We recommend that the fringing field should be mapped and warning signs be placed outside the 0.5mT (5G) contour. Entry to this region of higher field should be restricted to qualified personnel.

2 Ferromagnetic Objects

During operation the magnet exerts strong magnetic attraction towards ferromagnetic objects in the near vicinity. Loose objects can be accelerated to sufficient velocity to cause severe personnel injury or damage to the coils. Keep ferromagnetic tools clear.

3 Arcing

Magnets store considerable energy in their field during operation. Do not disconnect any current lead while under load or the magnetic field energy will be discharged across the interruption causing hazardous arcing.

4 Coil Hot Resistance

Do not exceed the maximum coil hot resistance given in the specifications or coil overheating and possible damage may occur.

5 Interlocks

These should always be connected if the magnet is to be operated unattended, to avoid the possibility of coil overheating caused by excessive power dissipation or inadequate cooling.

6 Watches, Credit Cards, and Magnetic Disks

Do not move magnetically sensitive items into the close vicinity of the magnet. Even some anti-magnetic watches can be damaged when placed in close proximity to the magnet during operation. Credit cards, and magnetic disks are affected by magnetic fields as low as 0.5mT (5G).

7 Trip Hazards

Caution must be taken when moving around the magnet as there are potentially cables on the floor that will present a trip hazard. It is highly advised that floor conduit be purchased that will cover the cables. This will also protect the cables from potential damage.

4. INSTALLATION

Caution: Take care when handling system. All movement, lifting and installation of the 5405 Electromagnet must be under the supervision of an experienced person to prevent the possibility of serious injury or damage to the electromagnet and associated equipment.

4.1. Unpacking Instructions and Damage Inspection

To unpack the electromagnet please the follow the procedure below.

1. **Inspect the shipping crate for obvious signs of damage or mishandling. Inspect whether the TiltWatch and/or ShockWatch sensors have been activated. If damage is evident report the damage in detail to the shipper for claim and simultaneously notify GMW in case assessment of the damage must be made. If no damage has occurred proceed with uncrating and installation.**

2. **First remove the steel banding and tek screws from the shipping crate cover. Lift the cover clear of the magnet and set aside, taking care to avoid tripping the TiltWatch or ShockWatch.**

3. **Remove the nut and washer stack securing the magnet to the base of the crate.**

4. **Take care in lifting the magnet from the crate for installation. Use assistance or lifting equipment if required.**

4.2. Siting Considerations

The 5405 Series is not magnetically shielded. Ferro-magnetic material in the vicinity of the magnet will modify the magnitude and uniformity of the central region magnetic field. As a general rule avoid magnetic material closer than approximately 1 meter of the central region.

Background fields such as the geomagnetic field and alternating field from 50/60Hz power sources are not shielded by the magnet and will add to the field produced by the magnet. If possible, these background fields should be measured and their effects evaluated prior to installation. It may be necessary to orient the magnet axis to minimize the effects of external fields, to relocate ac power sources or to install suitable magnetic shielding.

4.3. Mounting Holes

The 5405 Series electromagnets feature clearance slots in their mounting feet suitable for mounting to metric or imperial optical tables. In addition to the slots, the mounting feet feature four ⌀ 14mm mounting holes; spaced 495 x 220mm. Refer to Drawing 11907-0450-0_S1_P1 in section 4.9.

4.4. Rolling or Rolling/Rotating Base Mounting

1. **To mount on rolling base or rolling/rotating base lift magnet from BOTH EYEBOLTS high enough to clear top of base.**
2. **Slide rolling base or rolling/rotating base underneath, lower magnet to 12mm (0.5") above base top surface.**
3. **Position rolling base or rolling/rotating base so the tapped holes in the base are aligned with the angle mounting bracket holes. Lower the rolling base support legs until they contact the floor, to prevent the base from accidentally moving horizontally.**
4. **Lower magnet onto rolling base or rolling/rotating base assembly.**
5. **Secure magnet to rolling base or rolling/rotating base with M10 x 25 long Hex Head Bolts.**
6. **Raise the support legs and move magnet and rolling base or rolling/rotating base to desired location.**
7. **Screw down the four support legs located on each corner of the rolling or rolling/rotating base until the wheels clear the floor by 6mm (.25").**
8. **Secure the support legs with the locknut.**
9. **Secure rolling/rotating base to an adequate concrete floor to prevent movement and possible injury to personnel during an earthquake**

4.5. Electrical Circuit

Never connect or remove cables from the magnet with the power supply energised. The stored energy in the magnet can cause arcing resulting in severe injury to personnel or equipment damage.

Because the magnet stores a significant amount of energy in its magnetic field, special care should be taken to ensure that the current terminations are secure and cannot work loose in operation. Local heating at the terminations can cause rapid oxidation leading to a high contact resistance and high power dissipation at the terminals. If left unattended this can cause enough local heating to damage the terminals and the coils.

4.6. The 5405 Interlocks

The 5405 Series are fitted with four Selco 802L-070 thermostats. Two are mounted on each coil winding underneath the terminal covers. The thermostats are normally closed, opening when the coil temperature exceeds 70°C, ± 5°C.

In the event of any one of these interlocks opening, the power is cut from the power supplies and the system is de-energized. The temperature switches automatically reset once the proper operating conditions have been met.

In the event of an interlock tripping it is strongly recommended that the root cause of the trip be determined. In the event that the root cause cannot be determined please contact Tom King (tom@gmw.com) for technical support.

4.7. Cooling

The 5405 Series can be operated up to an average coil temperature of 70°C. Assuming an ambient laboratory temperature of 20°C and a temperature coefficient of resistivity for copper of 0.0039/°C, the hot resistance of the coil should not exceed 25% more than the ambient temperature "cold" resistance. The coil thermostat will open when any coil temperature exceeds approximately 70°C. Clean, cool (16°C - 20°C) water at 8 l/min and <4 bar (60 psid) must be used to cool the electromagnet.

The copper cooling tubes are electrically isolated from the coils to avoid electrochemical corrosion. A 50 micron filter should be placed before the input to the magnet to trap particulates.

Configuration Suggestion: For continuous operation of the magnet it may be appropriate to use a recirculating chiller to reduce water and drainage costs. The chiller capacity will depend on whether cooling is required for the magnet alone or magnet and power supply. For the Model 5405 Series Electromagnet with Kepco 1kW BOP power supply a suitable chiller is the Thermo Fisher TF9 recirculating water chiller (900W).

Avoid cooling the magnet below the dew point of the ambient air. Condensation may cause electrical shorts and corrosion.

During operation the resistance can be checked using a voltmeter across the magnet. The voltage will rise to a constant value once thermal equilibrium has been reached. If it is desired to save water, the flow can be reduced until the hot resistance is approached. NOTE: This adjustment must be made slowly enough to allow for the thermal inertia of the coils.

The magnet operated as a conventional water cooled electromagnet.

1. **Adjust the cooling water flow to approximately 8 liters/min (2.1 US GPM). For operation at less than maximum power the water flow may be correspondingly reduced. Note that the inlet water temperature will determine the actual flow rate required. The above specified flow rates were determined with a water inlet temperature of approximately 18°C.**
2. **Turn on the power supply and increase the current until the desired field is reached. Note that constant current operation is preferred for stable field performance. Please refer to the user manual of the selected power supply.**

The magnet operated as an air cooled electromagnet.

No test data is currently available for air cooled performance of the 5405 Series electromagnets. If operating as an air cooled electromagnet, it is advised to operate using the following procedure:

1. **When the 5405 is air cooled, the dominant method for cooling is from convection. Be sure that the magnet is freely ventilated, placing the magnet in a confined space will lead to over heating.**
2. **Apply a thermocouple to the outside of one of the coil windings. Turn on the power supply and slowly increase the current from 0 amps until the thermocouple reads 65°C. This will be the peak continuous current. Please refer to the user manual of the selected power supply.**
3. **Slight increases in performance can be achieved by blowing air over the magnet. Considerable increase in performance can be achieved by force cooling the magnet through the water cooling circuit. Be sure to use clean dry air and use the highest flow possible. The best performance under these circumstances will have to be determined on a case by case basis.**

It is strongly recommended that all the interlocks be connected and checked before using air cooling. With air cooling, if the current is set too high, the temperature can rise very quickly and may cause irreversible damage to the magnet.

4.8. Pole Selection and Installation (Refer to Drawing 11907-0450-0_S4)

Using the field uniformity and induction curves determine the most desirable pole; cylindrical or tapered. In general:

If a uniform field is required use a cylindrical pole end.
If a high field is required use a tapered pole end.

Note: Ensure that the poles are arranged so that the pole gap is approximately centered between the coils.

Pole removal procedure for 5403 Series electromagnets with adjustable pole gap (with reference to drawing 17907-0450-0_S4):

1. **Deenergize the electromagnet and turn off the power supply.**
2. **Adjust the poles (item 9) for maximum pole gap by rotating the Pole Adjustment Screws (item 6) clockwise until the poles are fully retracted.**
3. **Remove the eight cap screws securing the Pole Adjustment Caps (item 5) to the yoke (item 1).**
4. **Pull the pole and cap assembly approximately 75mm (3”) out from the magnet yoke.**
5. **Grip the cap with one hand and support the pole with the other hand. Remove the pole and cap assembly from the magnet carefully, to ensure that the pole face is protected from damage.**
6. **Remove the pole from the Pole Adjustment Cap by rotating the Pole Adjustment Screw counter-clockwise.**

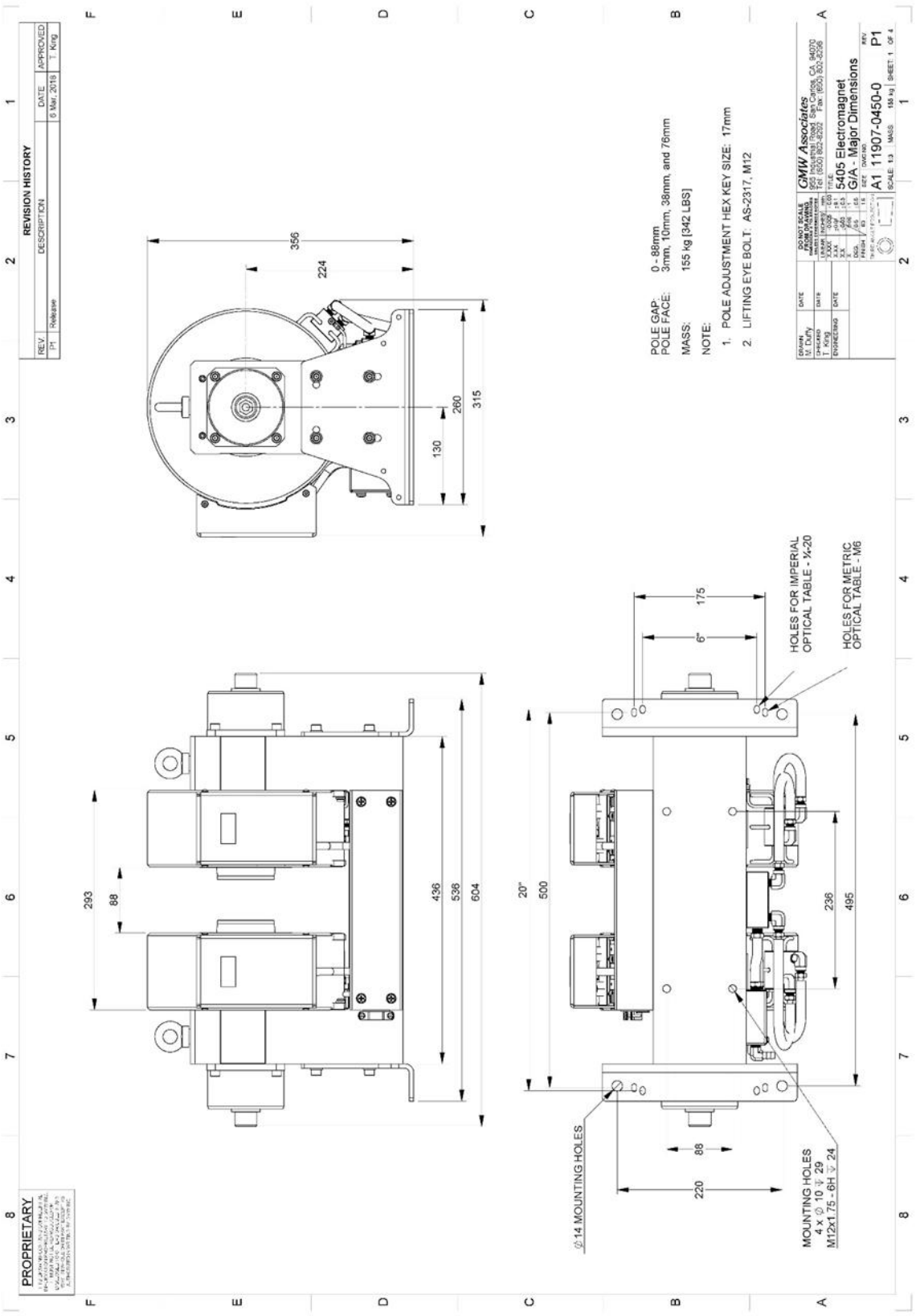
To install a pole, follow the above steps in reverse order ensuring that components are clean and free from debris.

Pole removal procedure for 5405 Series electromagnets with a fixed pole gap:

1. **Deenergize the electromagnet and turn off the power supply.**
2. **Remove the eight cap screws securing the Pole Retainer to the yoke.**
3. **Remove the Pole Retainer from the magnet yoke.**
4. **Remove the pole and any spacers from the magnet carefully, to ensure that the pole face is protected from damage.**

To install a pole, follow the above steps in reverse order ensuring that components are clean and free from debris. To set the desired pole gap, install spacers between the magnet yoke and the end flange of the pole. (Additional spacers are available from GMW.)

4.9. Drawing 11907-0450-0_S1_P1_5405_G/A_Major_Dimensions



5. OPERATION

5.1. General

The 5405 Series electromagnets are optimized to give maximum performance with water cooled operation. If operating air cooled, the magnet's performance will be significantly decreased. See section 4.7 for detail on magnet cooling configurations.

This product is an electromagnet and creates significant magnetic fields both within the magnet and in the surrounding area. Make sure that there are no ferromagnetic items, tools or components loose in a 1 meter radius surrounding the magnet.

The Model 5405 is not a shielded electromagnet. In operation the magnet fringing field can be in excess of 0.5mT (5G). This can cause malfunctioning of heart pacemakers and other medical implants. We recommend that the fringing field should be mapped and warning signs be placed outside the 0.5mT (5G) contour. Entry to this region of higher field should be restricted to qualified personnel

Do not move magnetically sensitive items into the close vicinity of the magnet. Even some anti-magnetic watches can be damaged when placed in close proximity to the magnet during operation. Credit cards, and magnetic disks are affected by magnetic fields as low as 0.5mT (5G).

5.2. Field Control Operation

The necessity to use calibration curves can be avoided by using a field controller to sense the magnetic field and provide a corresponding power supply control signal through the power supply programming inputs. Contact GMW for suitable instrumentation and software (Labview) (sales@gmw.com).

6. MAINTENANCE

Whenever performing maintenance on this magnet all electrical plug socket disconnects must be disconnected and a plug lockout device used to properly shut down the electrical system. Refer to Lockout/Tagout procedure defined in section 1.3.

6.1. Cooling Circuit

Check the cooling water circuit to ensure the water is clean and free of debris and bacterial growth. If an in-line water filter is used, ensure the filter is clean. If this magnet is used in conjunction with a closed cycle chiller please refer to the User Manual for details specific to that chiller for cleaning and maintenance.

6.2. Strain Relief Check

During the scheduled maintenance it is recommended that cables at the exit from the terminal cover of the 5405 Series Electromagnet be inspected for tight connection and absence of corrosion. In particular the strain relief should be checked to confirm that the cables are properly restrained from movement. The Lockout/Tagout procedure from section 1.3 should be followed during this procedure.

When inspecting cables to the magnet the magnet should be de-energized to zero amps and the power supply switched off.

6.3. Termination Inspection

Over time the electrical terminals can become loose, may begin to oxidise and strain relief may become degraded. Inspect the terminations at the power supply and at the magnet ends of the power leads. Oxidation can generally be removed using a wire brush for serious oxidation, or Emery cloth for light oxidation. Ensure that terminals are tight. If the strain relief is degraded or frayed it may be appropriate to replace the power leads.

7. STANDARD OPTIONS

7.1. Standard Pole Options

- **Poles for the 5405, 5405 FG, 5405 EG and 5405 ET electromagnets are available with faces of Ø3mm, 10mm, 38mm and 76mm as standard. See Section 9 for performance characteristics of the available pole faces.**

EPR poles are available upon request, these are custom optimized poles for a customer specified pole spacing.

Custom poles are also available for all 5405 Series electromagnets. These can be designed to particular customer requirements. Please contact GMW for more information sales@gmw.com.

7.2. Overbar Yoke Extension

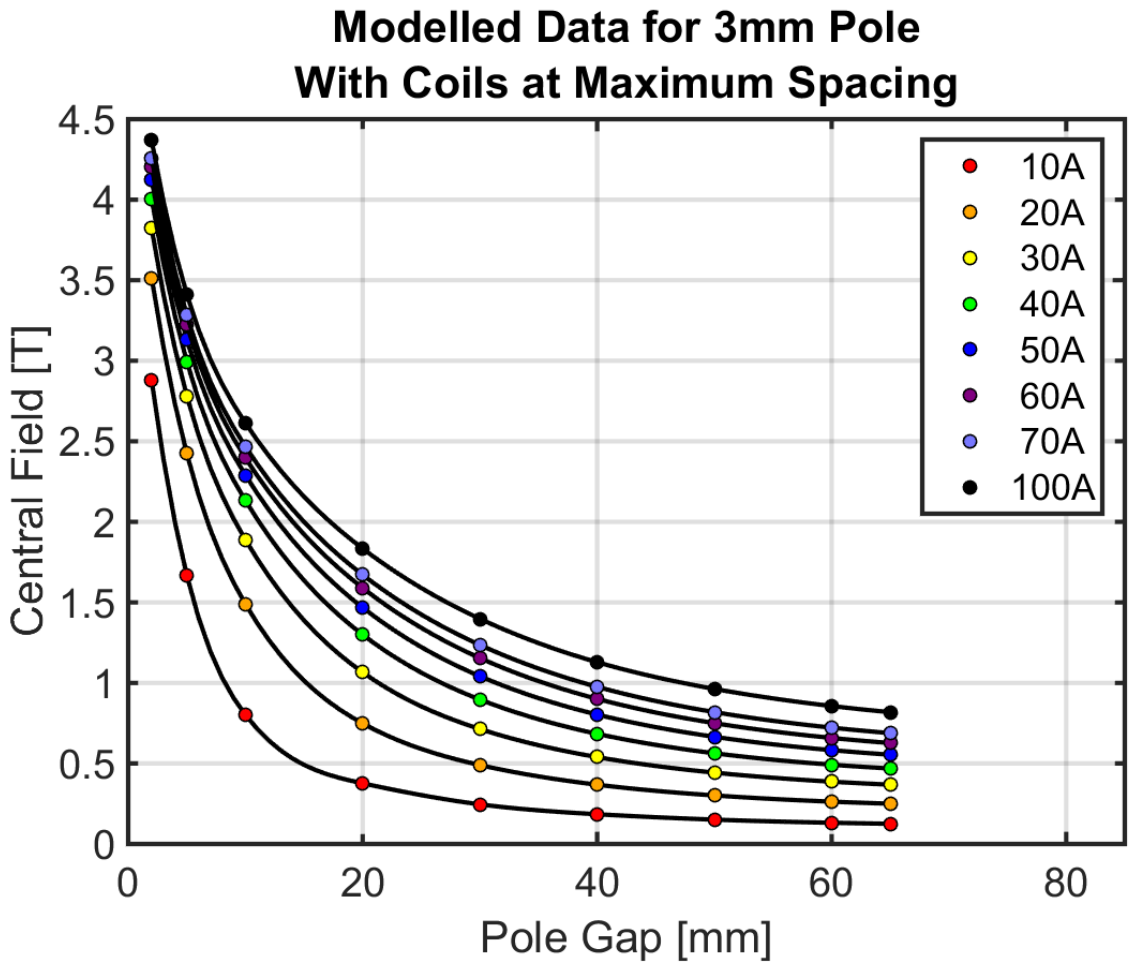
In applications where high field uniformity is required (i.e. NMR & EPR), GMW offers an Overbar to extend the 5405 C-Frame yoke into an H-Frame configuration. The addition of the Overbar provides a small increase in field strength however the main improvement is increased field uniformity due to geometric symmetry.

8. CUSTOM OPTIONS

The 5405 Series electromagnets can have customized performance by means of switching out the standard pole with a customized pole. GMW Associates will work with customers to provide the magnetic design of custom poles and will also manufacture such poles. Please direct inquiries to sales@gmw.com

8.1. Application Note: Ferromagnetic Resonance

A pole with a 3mm pole face has been designed to create peak field across a 2mm pole gap for the purposes of FMR analyses.

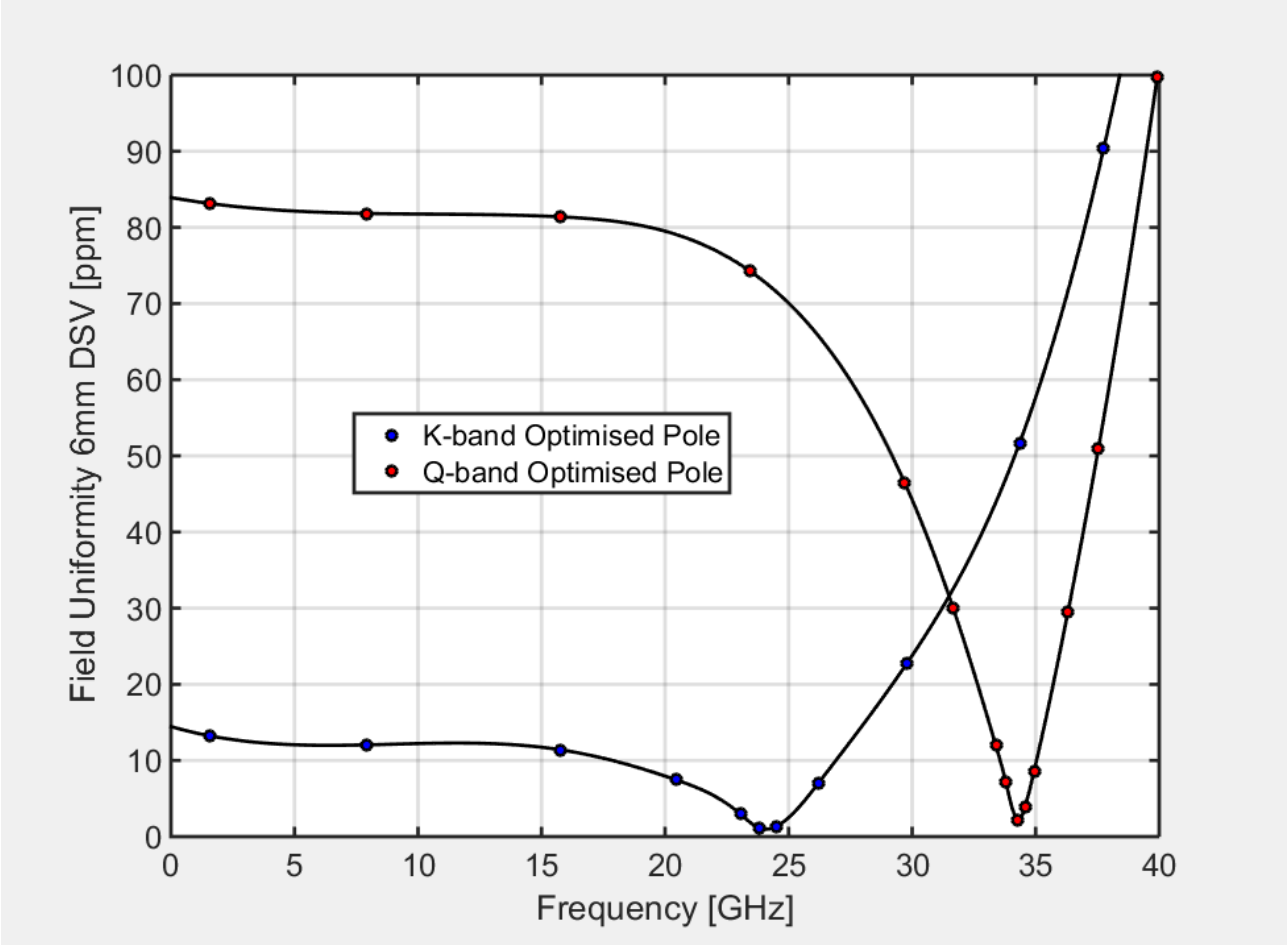


For any specific pole gap an optimized pole is available, on request, which will provide best performance for that specific pole gap.

8.2. Application Note: EPR Spectroscopy

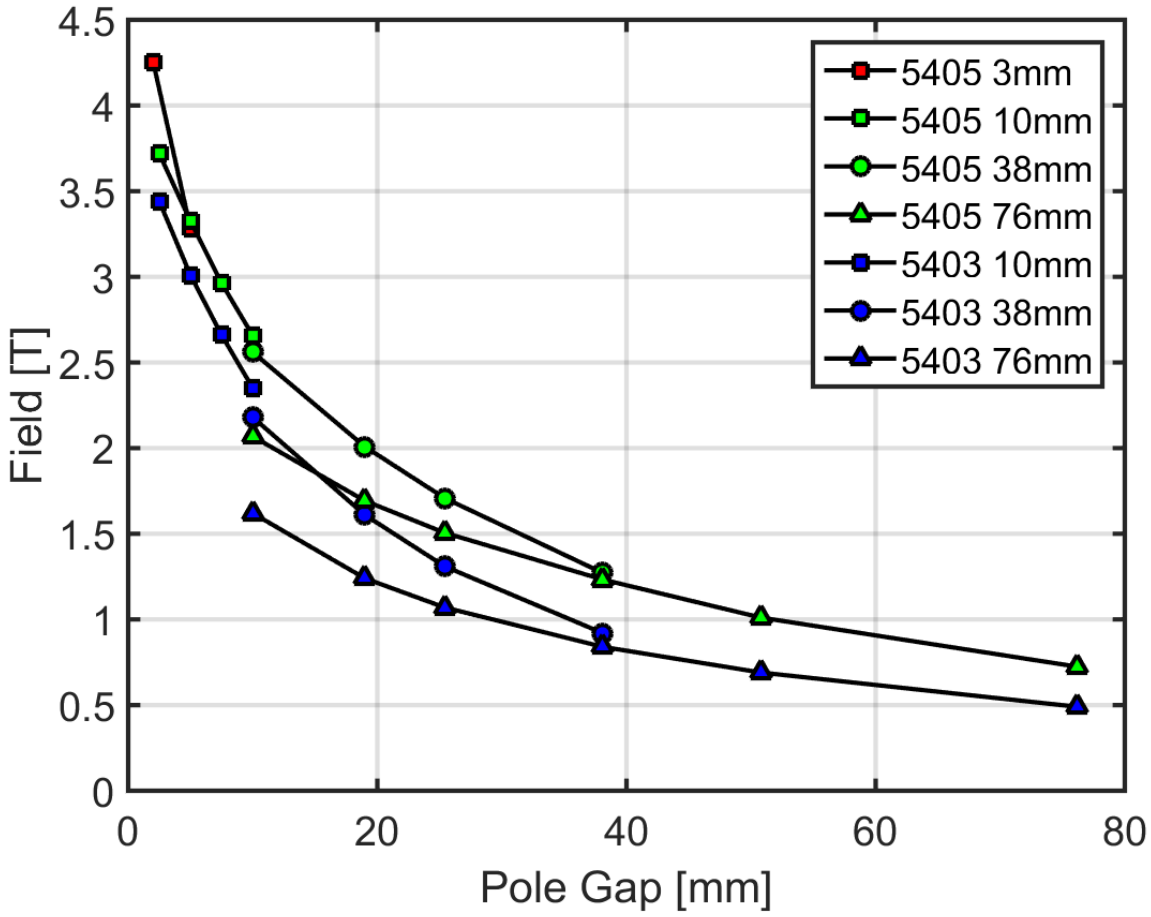
GMW offers poles optimised for EPR applications. Two examples are shown below for pole face spacing of 14mm. Each pole gives good uniformity across the excitation range for frequencies up to 40 GHz but each is optimised to give excellent field uniformity at either K-band or the Q-band. Similar custom poles are available on request for any frequency in the 0-40GHz frequency band.

Waveband	L	S	C	X	P	K	Q	U	V
λ [mm]	300	100	75	30	20	12.5	8.5	6	4.6
f [GHz]	0.8-1.2	3.4-3.8	4	9-10	15	24	34	50	65
B [T]	0.035	0.13	0.14	0.34	0.54	0.85	1.22	1.8	2.3

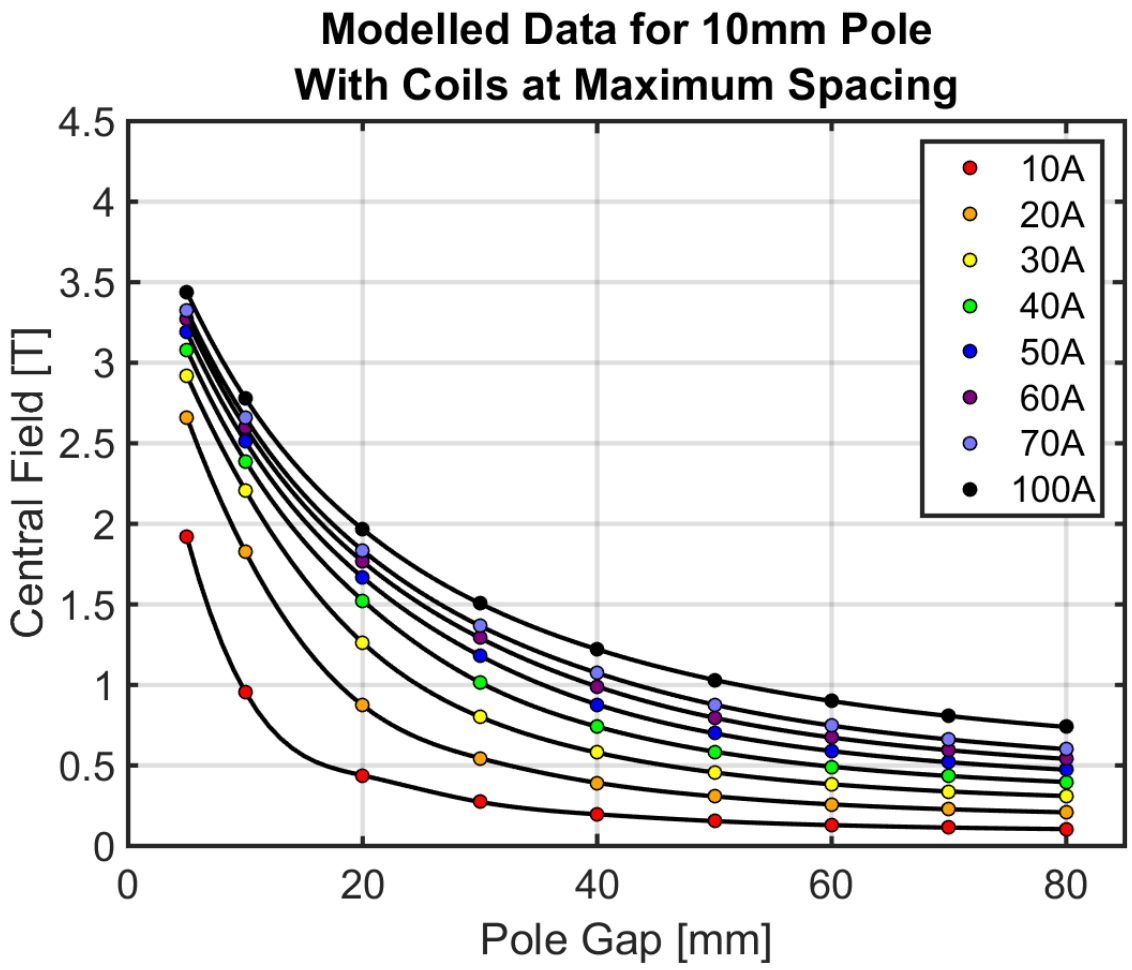


9. EXCITATION CURVES AND FIELD UNIFORMITY

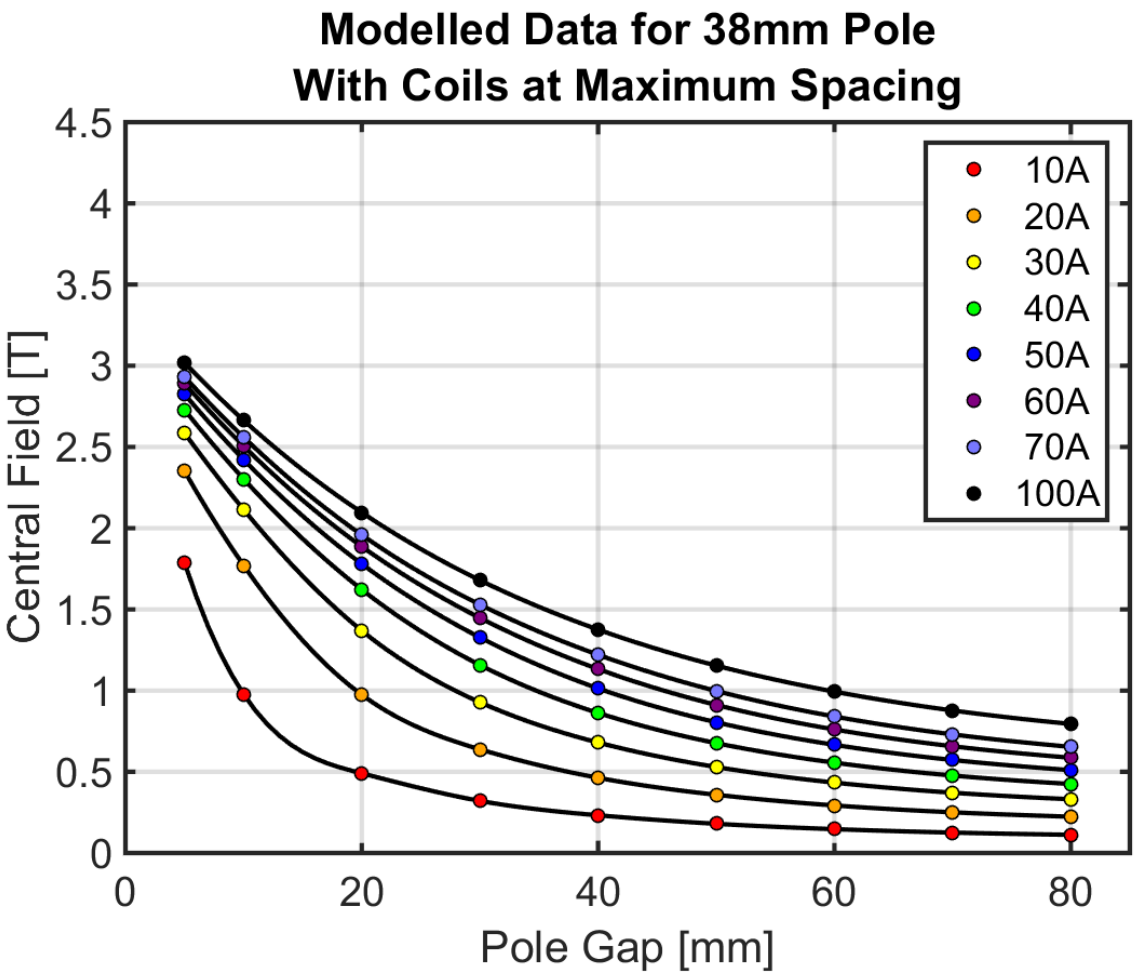
9.1. Comparison between 5403 and 5405 Performance



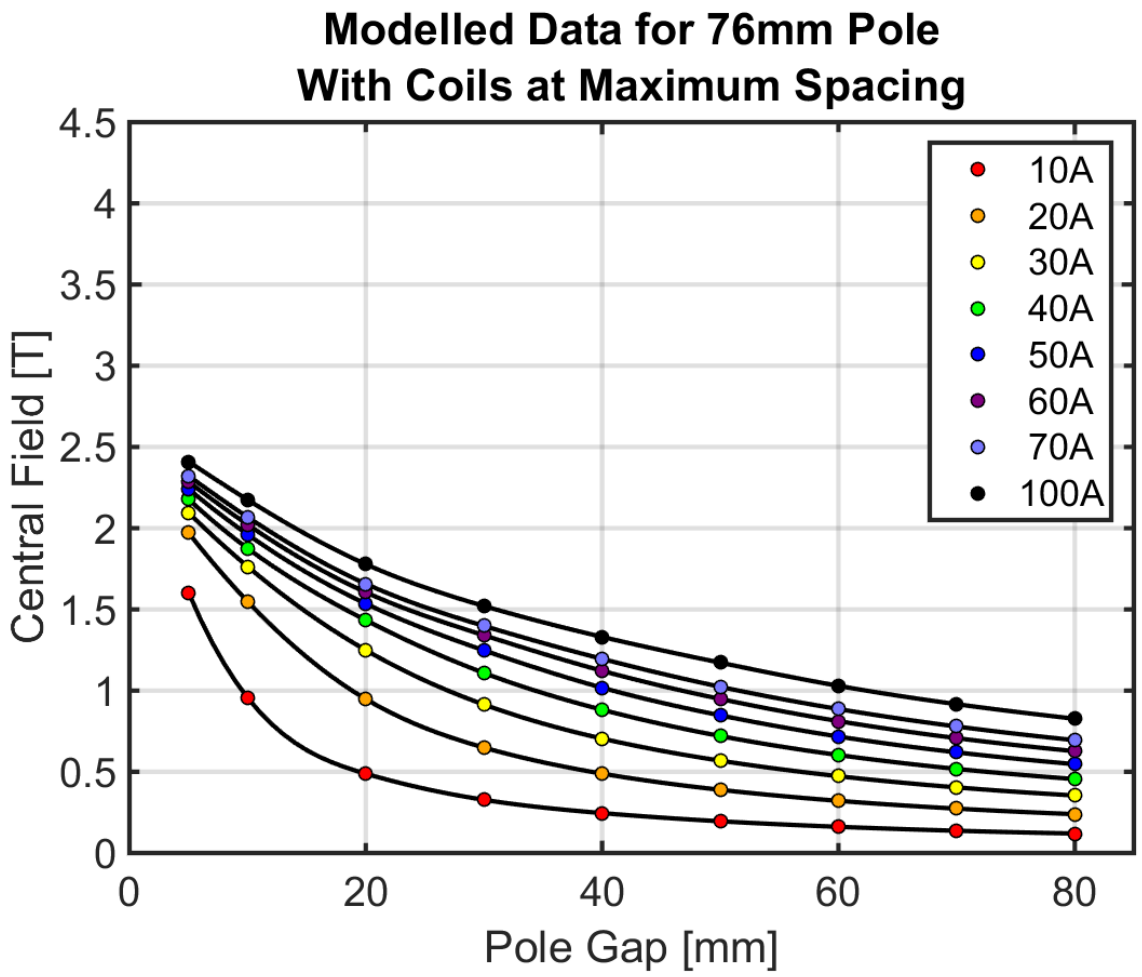
9.2. Performance of 10mm pole



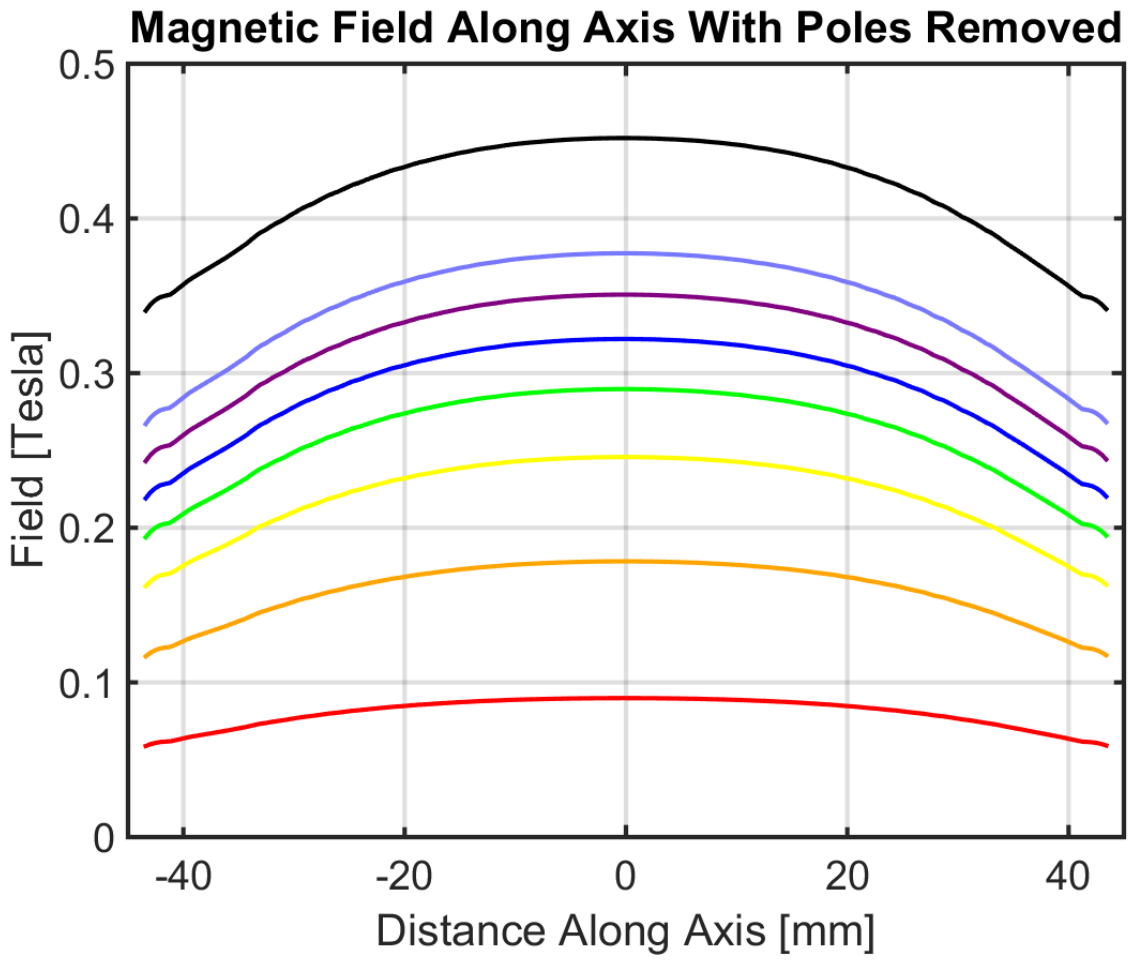
9.3. Performance of 38mm Pole



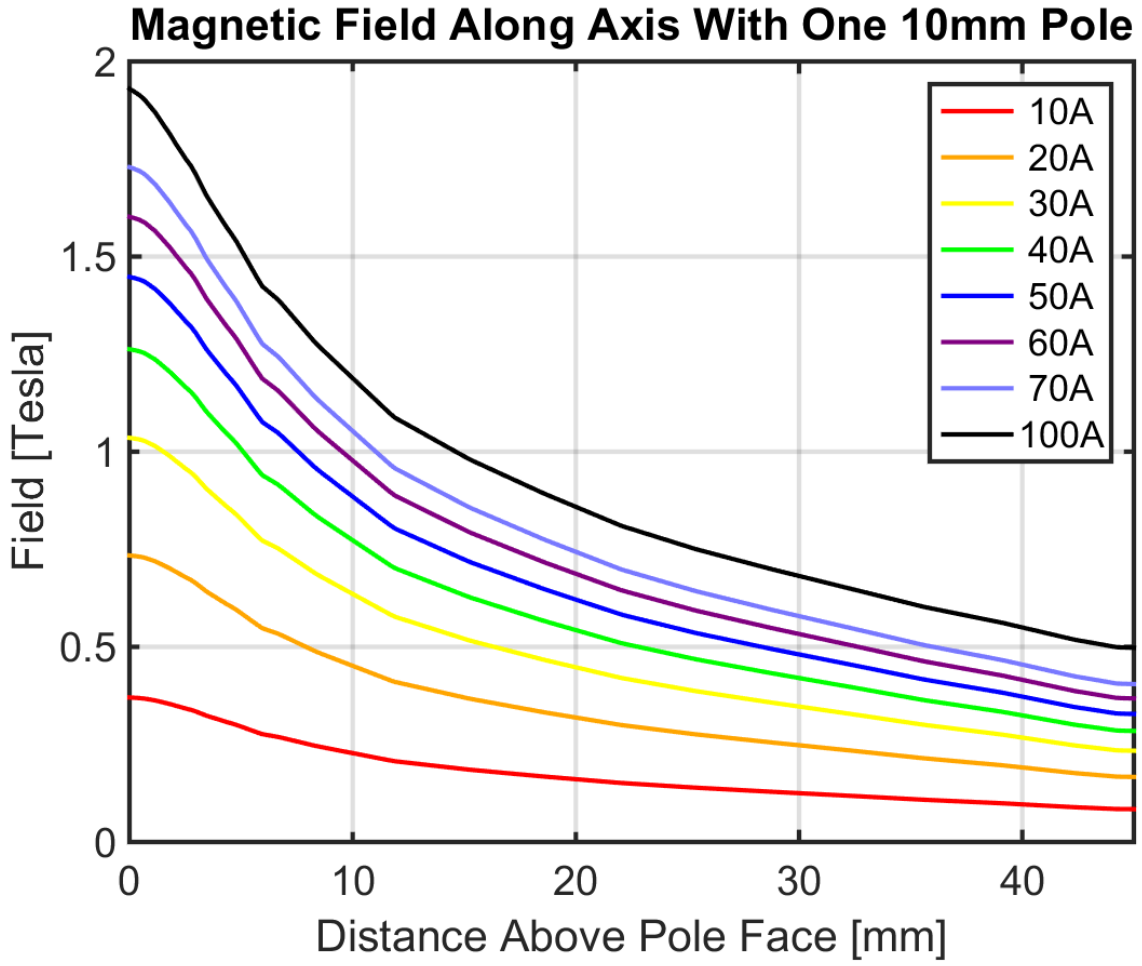
9.4. Performance of 76mm Pole



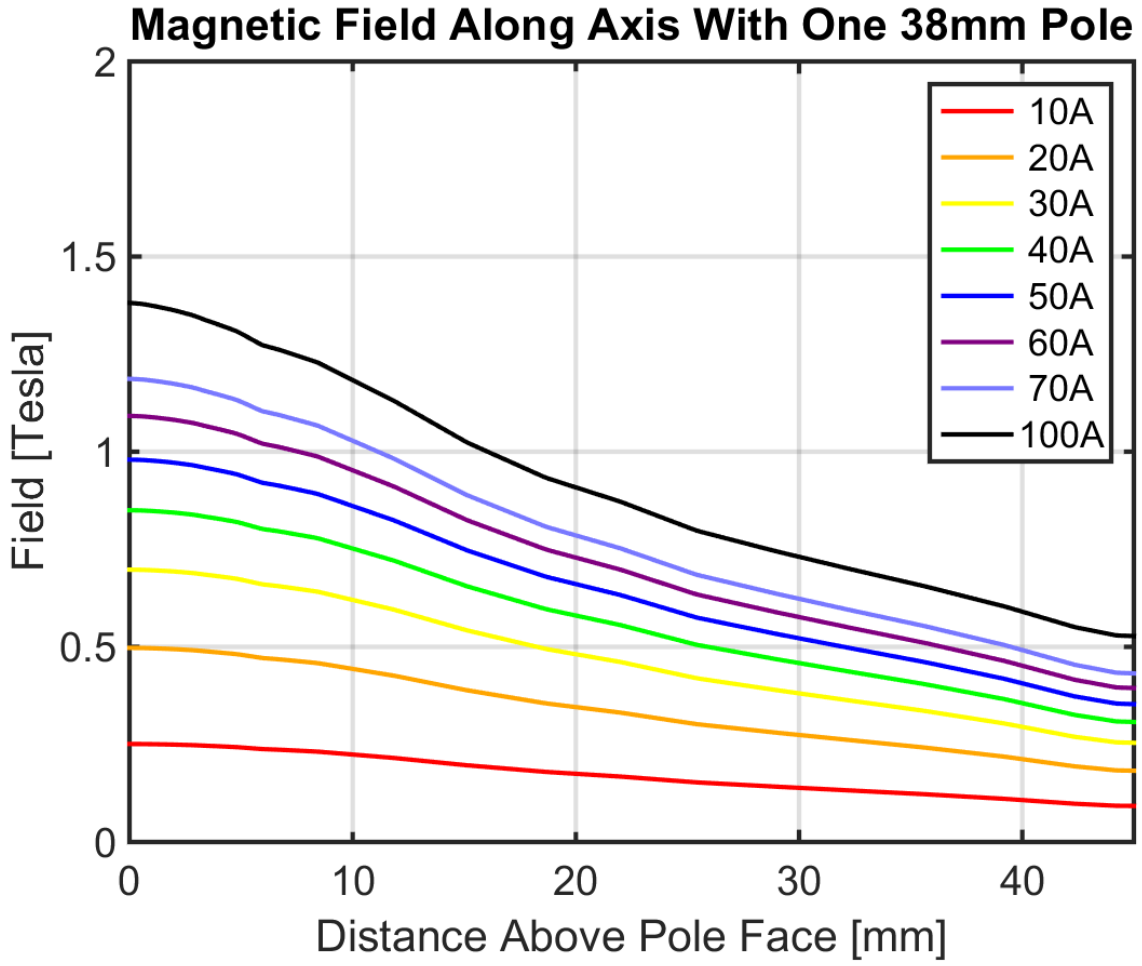
9.5. Field Uniformity With Poles Removed



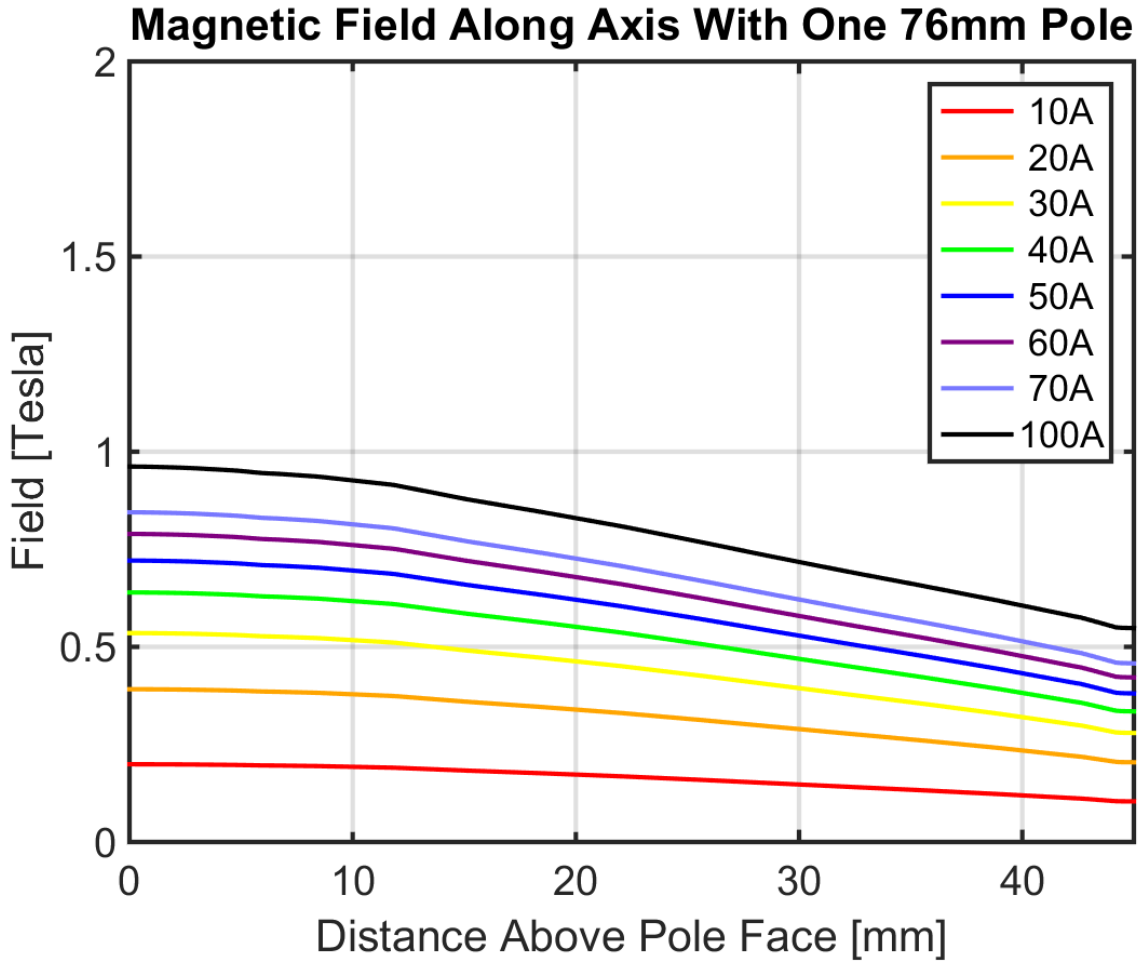
9.6. Field Uniformity With One 10mm Pole



9.7. Field Uniformity With One 38mm Pole



9.8. Field Uniformity With One 76mm Pole



10. 5405 FG (Future Development)

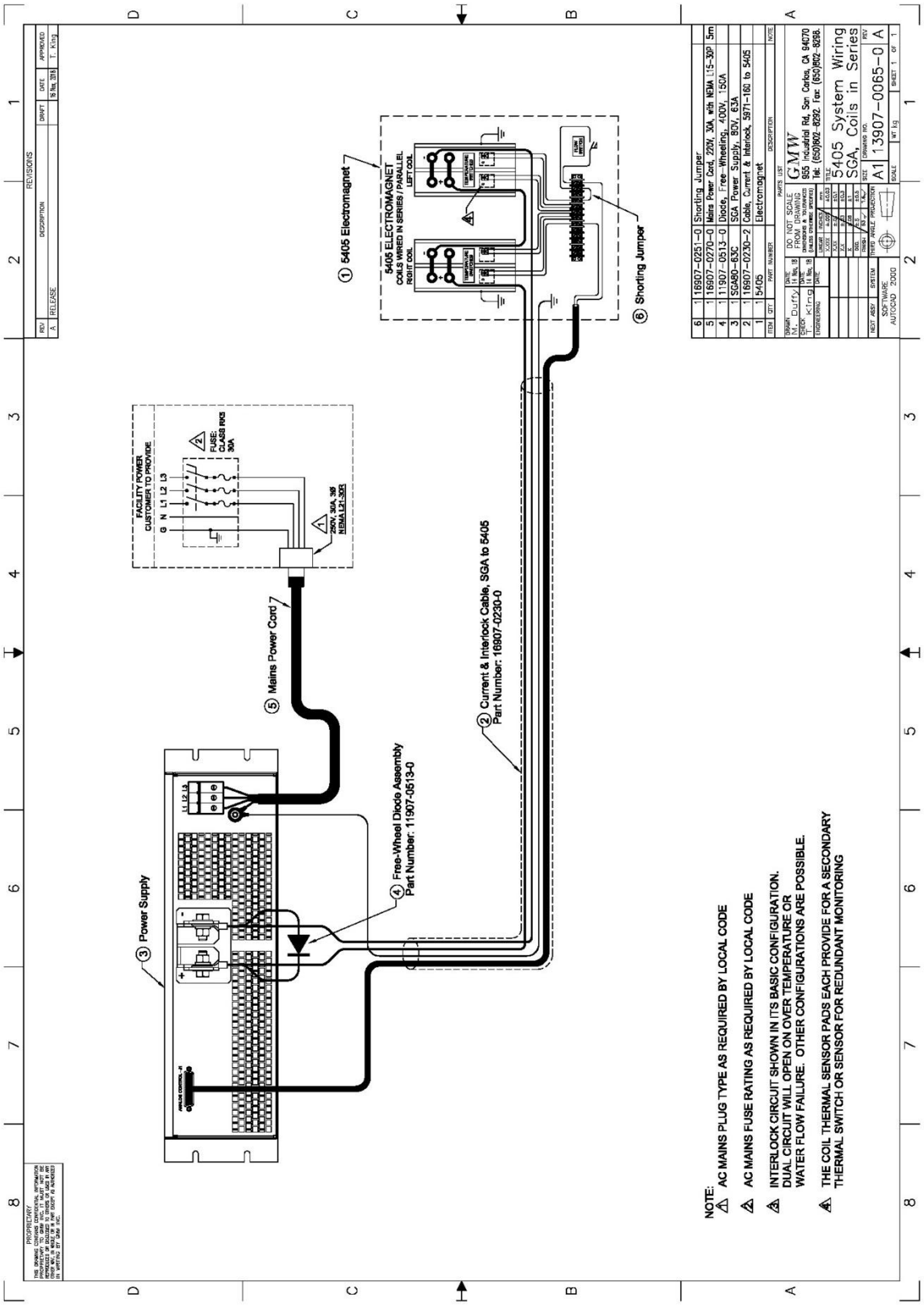
11. 5405 EG (Future Development)

12. 5405 ET (Future Development)

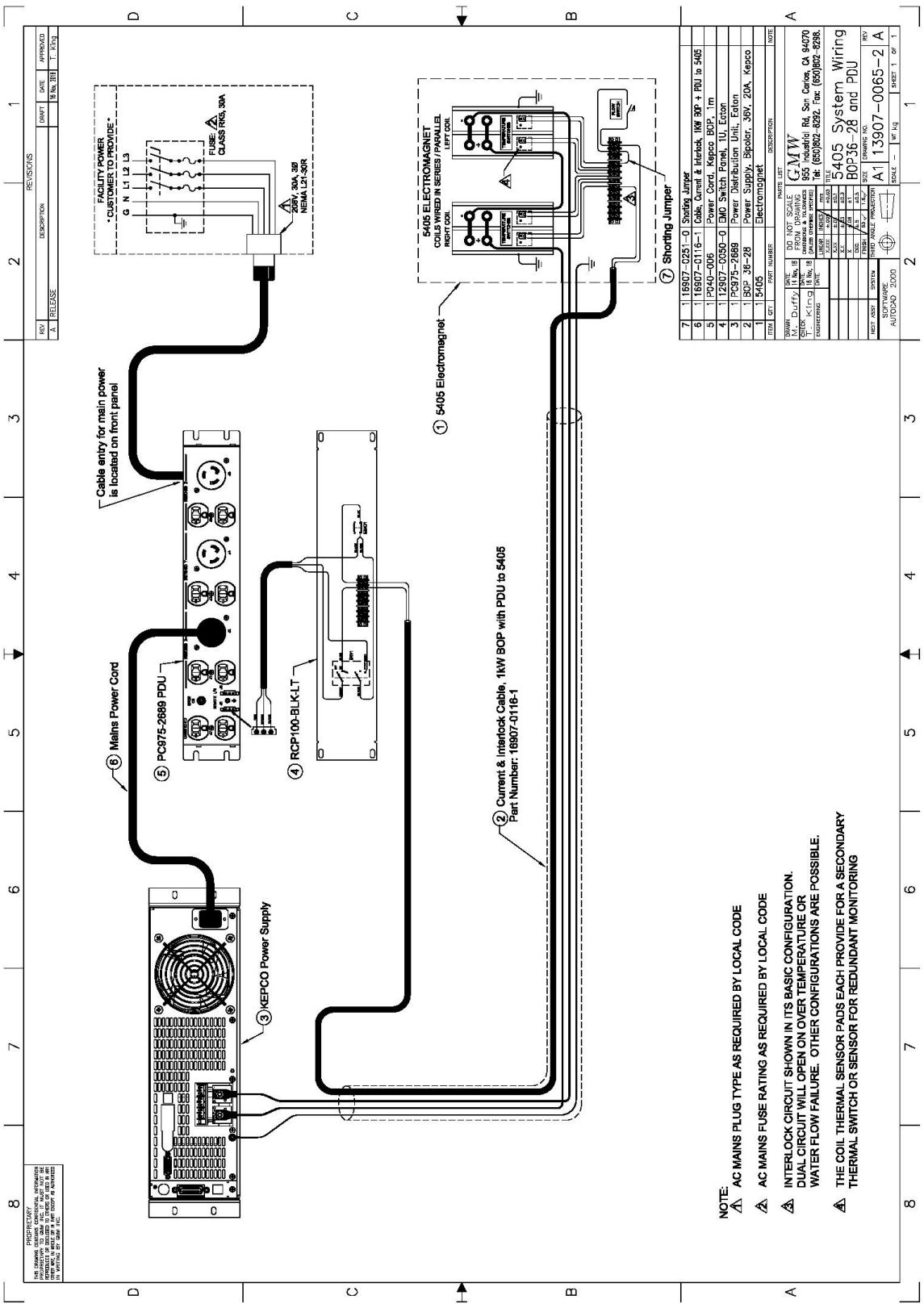
13. TEST DATA

14. WIRING DRAWINGS

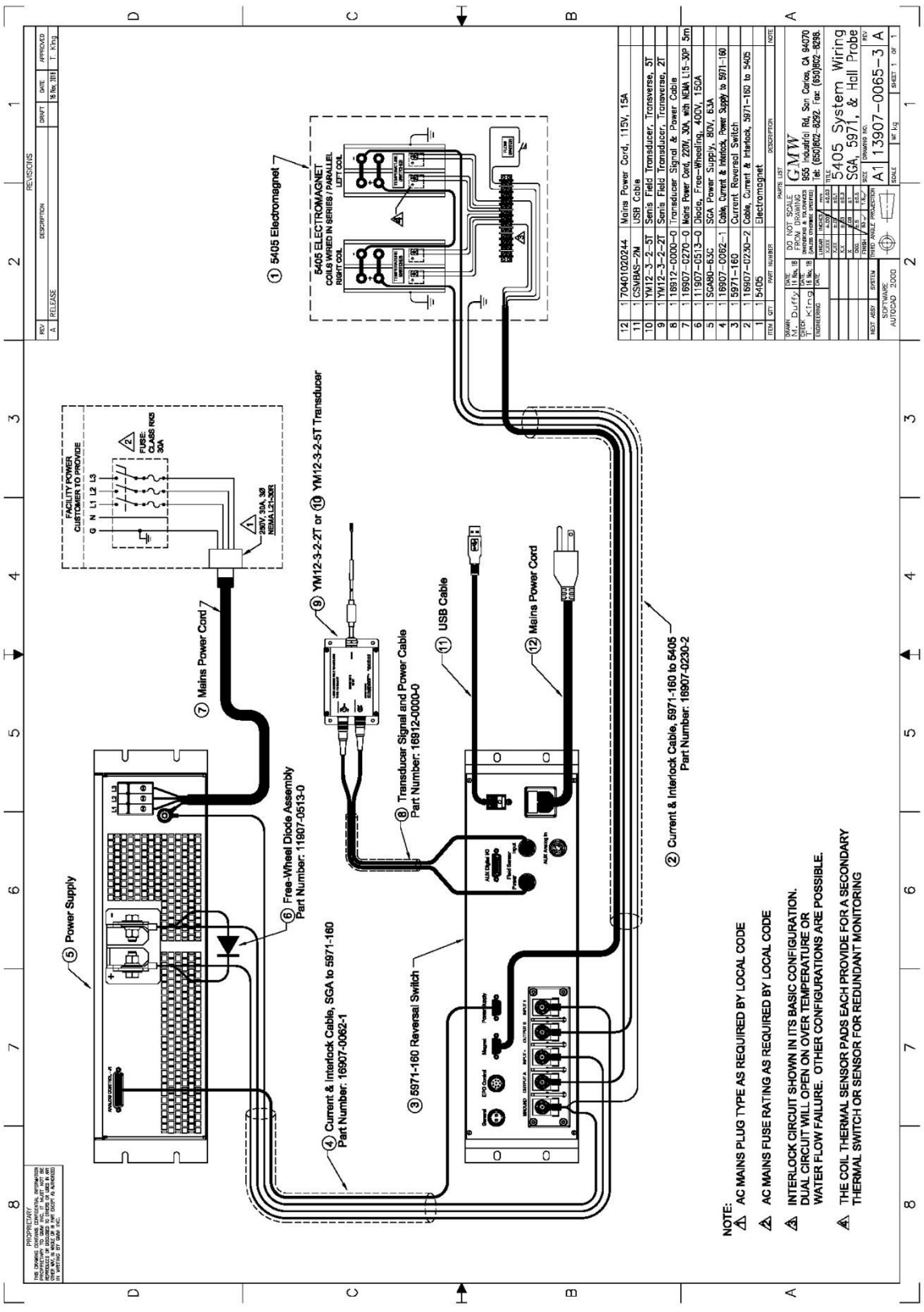
14.1. Drawing 13907-0065-0_A 5405 System Wiring For SGA 80V 63A In Series Connection



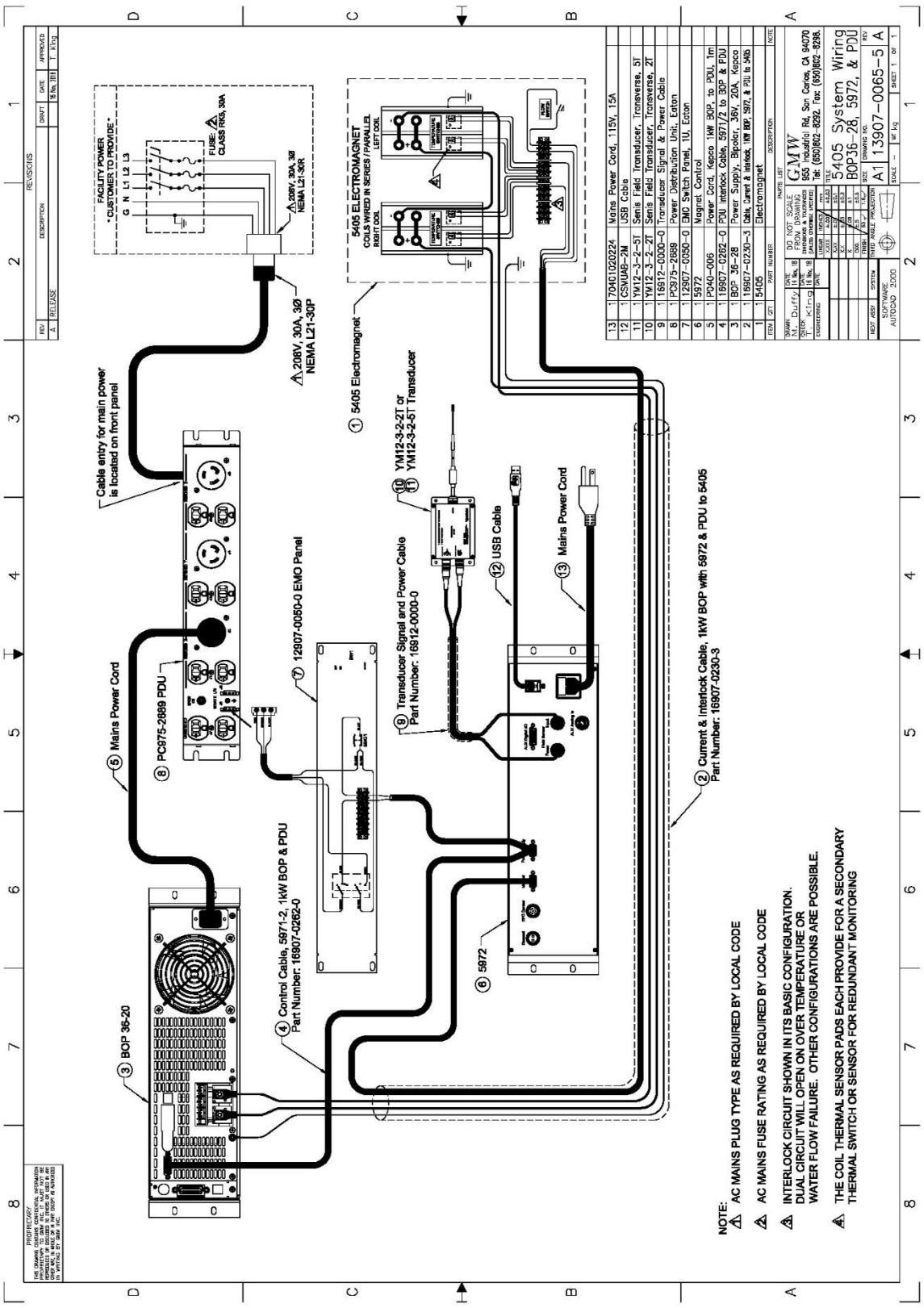
14.2. Drawing 13907-0065-2_A 5405 System Wiring For Kepco 1kW BOP Series/Parallel



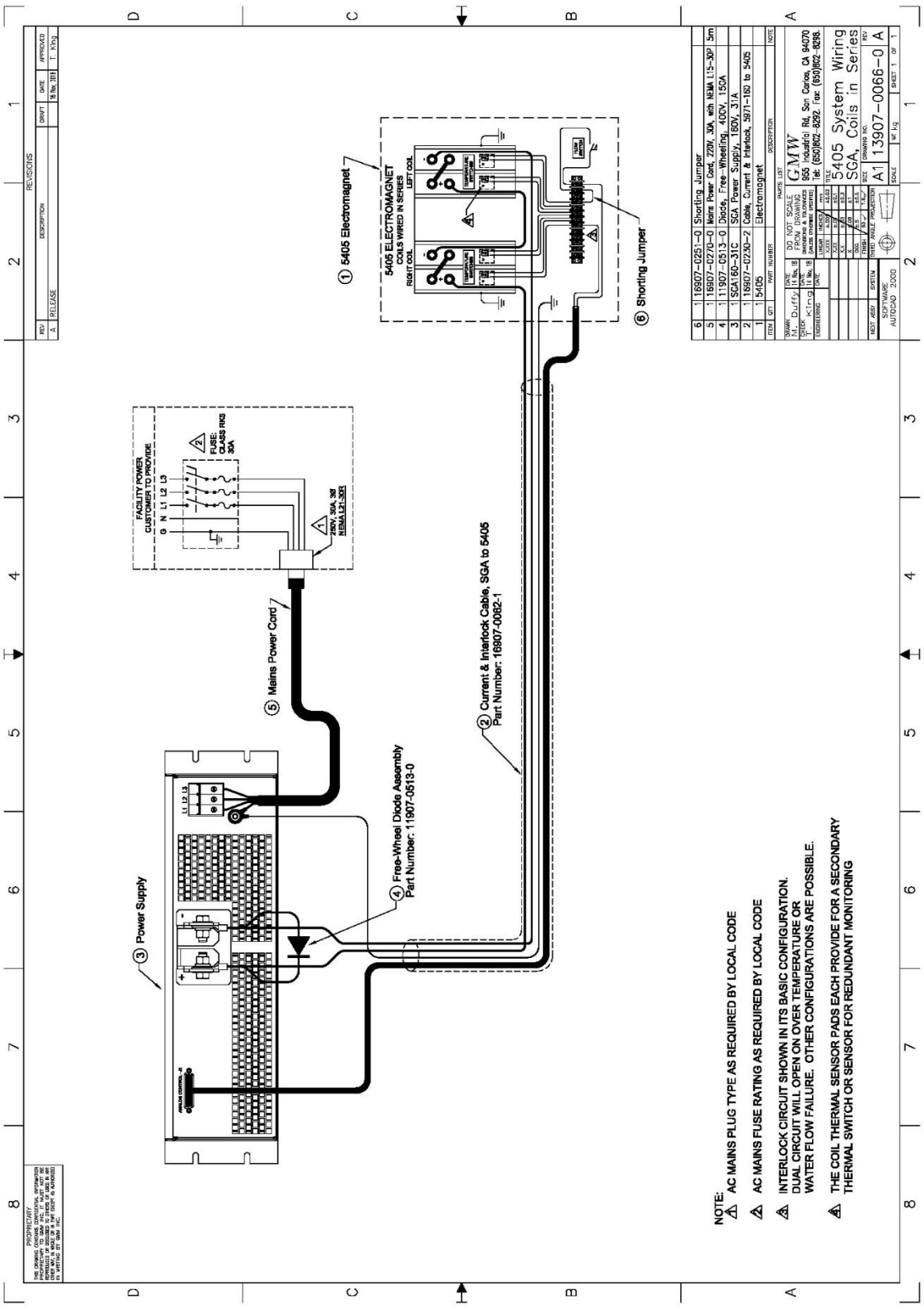
14.3. Drawing 13907-0065-3_A 5405 System Wiring For SGA Supply with 5971 Switch



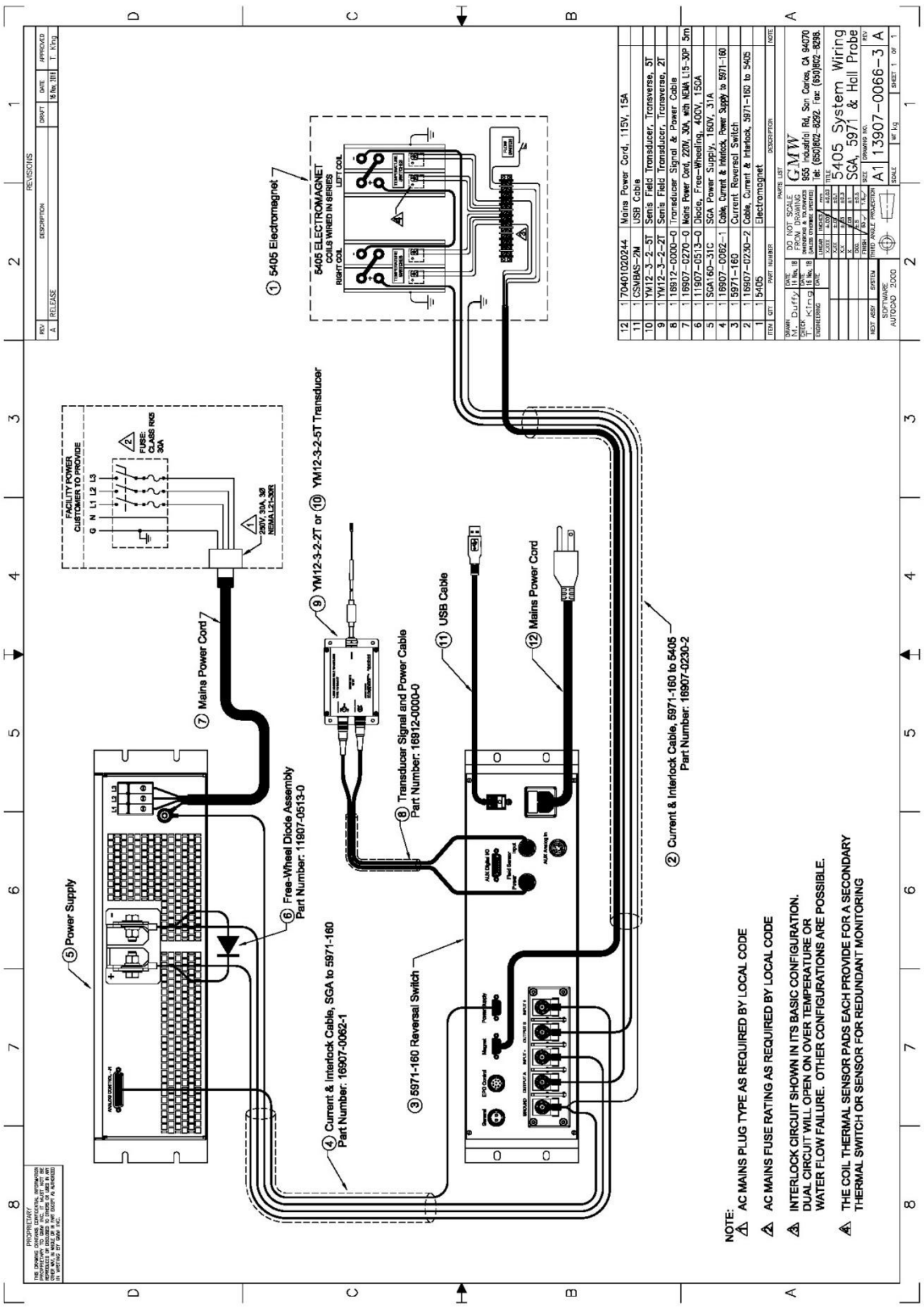
14.4. Drawing 13907-0065-5_A 5405 System Wiring For BOP36-28 with 5972 and PDU



14.5. Drawing 13907-0066-0_A 5405 System Wiring For SGA with Coils in Series



14.6. Drawing 13907-0066-3_A 5405 System Wiring For SGA with 5971 and Hall Probe



14.7. Drawing 11907-0450-0_P1 5405 General Assembly and Connection Configurations