The High Energy Electromagnetic Field Generator (HEEMFG)

Naval Innovative Science & Engineering (NISE) – Basic and Applied Research (219BAR-17-009)

UNCLASSIFIED/FOUO

AIR 4.4T

Objective: Design a test article and instrumentation to demonstrate the experimental feasibility of achieving high, electromagnetic (EM), field-energy, flux values toward the design of advanced High energy Density / High Power propulsion systems

Product Description: Test apparatus, instrumentation and operational method to prove that by coupling an electrically charged system's high frequency of axial spin (possibly coupled with high vibration frequencies) operated in a rapidly accelerated transient mode, we can achieve extremely high electromagnetic field-intensity (EM energy flux) values.

Warfighter Benefit: Realization of this technology moves propulsion technology beyond gas dynamic systems and enables the design of a field propulsion-based hybrid aerospace-undersea craft.

Transition Details: ONR, NRL, DARPA - possible continuation of project funding to be provided by these DOD agencies.

Transition Sponsor: If the feasibility study determines this experiment can be conducted at PSEF, funding will be pursued to build the test asset and run the test.

Transition Date: 9/30/2019 (Planned)

NAE Gap/STO: Strike Operations (STK)/STO-1: Responsive Engagement

Total S&T Funding: $515.30K

Technical point of contact: (b) (6) [redacted] (b) (6) [redacted] (b) (6) [redacted]

Other Partners: (b) (6) [redacted] (b) (6) [redacted]

The High Energy Electromagnetic Field Generator (HEEMFG) (219BAR-17-009)

PI: Dr. Salvatore Cezar Pais, (b) (6) [redacted] / **Assoc. PI:** (b) (6) [redacted]

Naval Innovative Science & Engineering (NISE) – Basic and Applied Research (BAR) **Location: NAS PAX, PSEF, RSF**

Objective: Design a test article and instrumentation to demonstrate the experimental feasibility of achieving high, electromagnetic (EM), field-energy flux values toward the design of advanced high energy density / high power propulsion systems.

Technical Approach:

- By coupling an electrically charged system's high frequency of axial spin (with accelerated vibration), operated in a rapidly accelerated transient mode, this project could achieve extremely high electromagnetic field-intensity (EM energy flux) values.
- This experimental investigation has several tasks, namely to design the experiment, the test asset, the associated instrumentation, the power requirements, and then to perform Spin Test.

NAWCAD Benefit:

- Realization of this HEEMFG technology moves the propulsion and power arena beyond gas dynamic systems and enables the design of a field propulsion-based hybrid aerospace-undersea craft, capable of multi-domain missions. Controlled Motion of electrically charged matter (from solid to plasma) via Accelerated Spin and/or Accelerated Vibration under Rapid Acceleration Transients , can result in high intensity electromagnetic energy flux, thereby resulting in novel energy harvesting and generation techniques and devices. These devices can greatly enhance NAVAIR/NAWCAD's electronic warfare technologies arsenal. Moreover, this work can result in the enablement of Macroscopic Quantum Coherence, that is the engineering of macroscopic states to behave as if quantum mechanical in nature - this is revolutionary for the Emerging field of Quantum Technologies, with applications in Quantum Computing, Spintronics, Artificial Intelligence, Crypto., etc.
- Furthermore, this technology has National Security importance in leading to the generation of thermonuclear Fusion Ignition Energy with commercial as well as military application potential, in ensuring National Energy Dominance.

Accomplishments:

- Completed preliminary experiments / test asset charging / EM flux detector mfg.
- Will complete test asset design and perform Spin Test to detect HEEMFG effect.
- Published: Dr. S. Pais, (2017, October 02). High Frequency Gravitational Waves -Induced Propulsion. *SAE Technical Paper 2017-01-2040*, doi: 10.4271/2017-01-2040.
- Application filed: Dr. S. PAIS, (2018, March 22). Plasma Compression Fusion Device. Tracking number: Serial # 15928703 (Navy Case PAX 285).

External Collaborator(s):

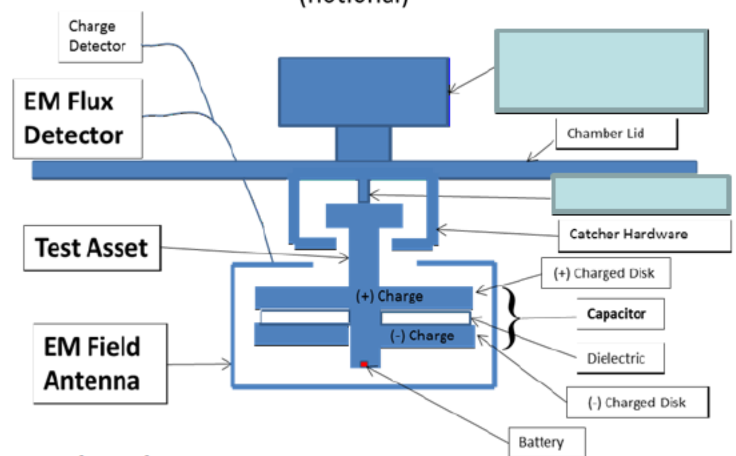
- None at this time.

Likely Customer(s):

- NAWCAD; possible engagement with DARPA, ONR, NRL, AFRL, NASA, etc.

HEEMFG Spin Rig

(notional)



Technical Maturity:
Research: Basic
Starting TRL: 2 **Est. Ending TRL:** 3

Technical Alignment:
Core Capability: High Energy Density / High Power Propulsion Systems

NAE Gap/STO: Power and Energy Technology / Advanced Naval Power Systems

Total Project Funding				
	FY17	**FY18**	**FY19**	**Total**
Labor	$144.4K	$127.6K	$117.3K	$389.3K
Travel	$5.00K	$5.00K	$0.00K	$10.00K
Material	$2.53K	$65.00K	$0.00K	$67.53K
Total	$151.9K	$197.6K	$117.3K	$466.8K

The High Energy Electromagnetic Field Generator (HEEMFG) (219BAR-17-009)

UNCLASSIFIED/FOUO

4.4T

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Warfighter Benefit: Realization of this technology moves propulsion technology beyond gas dynamic systems and enables the design of a field propulsion-based hybrid aerospace-undersea craft.

Transition Details: ONR, NRL, DARPA - possible continuation of project funding to be provided by these DOD agencies.

Transition Sponsor: If the feasibility study determines this experiment can be conducted at PSEF, funding will be pursued to build the test asset and run the test.

Transition Date: 9/30/2019 (Planned Transition Date)

NAE Gap/STO: Strike Operations (STK)/STO-1: Responsive Engagement

Total S&T Funding: $197.6K

Technical point of contact: Dr. Salvatore (b) (6) [redacted]

Other Partners: (b) (6) [redacted]

The High Energy Electromagnetic Field Generator (HEEMFG)
(219BAR-17-009)

Naval Innovative Science & Engineering (NISE) – Basic and Applied Research

Key Performers / Teams:

Research Location: Patuxent River, MD

PI: (b) (6) [redacted]

(b) (6) [redacted]

Funding Type/Source: 219 BAR

FY17
$152K

Last Updated:

Objective/Introduction:

- Design a test article and instrumentation to demonstrate the experimental feasibility of achieving high, electromagnetic (EM), field-energy, flux values toward the design of advanced High energy Density / High Power propulsion systems.

Approach/Method and Implications:

- By coupling an electrically charged system's high frequency of axial spin with high vibration frequencies operated in a rapidly accelerated transient mode, this project could achieve extremely high electromagnetic field-intensity (EM energy flux) values.

DoD/Naval Impacts/Benefits:

- Realization of this technology moves propulsion technology beyond gas dynamic systems.

Strategic Knowledge Product(s):

- Findings anticipated to be submitted for publication in AIAA or SAE technical journals.
- It is expected any products from this experiment will transition to the Naval Air Warfare Center.

Transition Programs/Sponsors:

- If the feasibility study determines this experiment can be conducted at PSEF, funding will be pursued to build the test asset and run the test.

FOUO

Basic and Applied Research Technical Proposal

Subtype

Basic Research

Section 1 – Project Overview

Proposal Title

The High Energy Electromagnetic Field Generator (HEEMFG)

Principal Investigator

Name: (b) (6) [redacted]

Code: 4.4.5.1

Phone: (b) (6) [redacted]

Email: (b) (6) [redacted]

Associate Investigator

Name: (b) (6) [redacted]

Code: 4.4.5.1

Phone: (b) (6) [redacted]

Email: (b) (6) [redacted]

STAIRS Tracking and Project Details

The STAIRS tracking information below is for reference only. These details can be modified in the Edit Proposal Package Details interface in STAIRS.

T-Code: 4.4T

Portfolio: NAWC

Estimated start date: 10/3/2016

Estimated end date: 9/30/2017

NAWC lab: AD

Starting TRL: TRL 2: Technology concept and/or application formulated.

Estimated TRL at completion: TRL 2: Technology concept and/or application formulated.

Funding Summary

The funding summary below is derived from the cost proposals entered in STAIRS for this proposal package. It is for reference only. To modify funding amounts, please edit the cost proposals using the STAIRS interface.

Fiscal Year	Labor	Travel	Materials	FY Total
2017	$151.96K	$0.00K	$0.00K	$151.96K
			Total:	**$151.96K**

Section 2 – Objective

Objective

Clearly and concisely state the overall objective and deliverable(s) of the project in one to three sentences. **Do not include any government proprietary information.**

Design a test article and related instrumentation as part of a one-year study to demonstrate the experimental feasibility of achieving high, electromagnetic (EM), field-energy, flux values toward the design of advanced concepts for High Density / High Power systems under the 4.4 Core Capability of Power and Energy Systems. The PIs will deliver technical reports and possible journal publications based on the results of this study with the intent to quantify expected EM energy flux.

Reduced Total Ownership Cost (RTOC)?

Will this project help reduce total ownership cost?

No

Improved / Increased Readiness?

Will this project help improve or increase readiness?

No

Section 3 – Approach

Technical Approach

Clearly state the hypothesis, provide a concise background description, and describe theoretical/ experimental methodology to achieve your objectives.

Hypothesis:

By coupling an electrically charged system's high frequency of axial spin with high vibration frequencies (i.e., abrupt pulsations/harmonic oscillations) operated in an accelerated mode, this project could obtain extremely high, electromagnetic, field-intensity values.

Background description:

This concept's governing physics entail the coupling of Gyration (high-frequency spin), Vibration (high-frequency abrupt pulsations / harmonic oscillations), and possible Curvilinear Translation (i.e., non-axial rotation or linear displacement) of electrically charged systems. As such, EM field-energy flux values on the order of 10^{33} Watts/m^2 (i.e., complete [quantum] vacuum polarization) are theoretically feasible with the concept at hand in an accelerated high frequency spin and accelerated vibration operational mode.

These extremely high EM, field-intensity values emphasize the novelty of this concept and are especially suited for the design of energy generation machinery with power output levels much higher than those currently achievable. The utilization of such high power sources for aerospace power and propulsion generation, as it pertains to reduction in a hybrid craft's inertial (or gravitational) mass as a direct result of local Vacuum Polarization, is an important application of the described concept. In this manner, extreme hybrid aerospace / undersea craft (HAUC) speeds can be achieved.

Refer to the technical paper entitled "The High Energy Electromagnetic Field Generator (HEEMFG)" attached to the STAIRS project proposal for additional explanation of the advanced physics associated with this project. Also, refer to the Test Plan summary attached to the STAIRS proposal for a better understanding of testing measurands.

Theoretical/Experimental Methodology:
A one-year feasibility study to demonstrate the experimental ability to fully address the concept of HEEMFG is proposed. The intent of this study is design of the test asset and detailed design of the experiment. If successful, subsequent years' efforts could include building the test asset, instrumenting it, and conducting the experiment in Propulsion System Evaluation Facility's (PSEF) Rotor Spin Facility (RSF). Safety of test will dictate a build-up approach to testing where the RPMs, complexity of test asset shape, accelerations, and vibration amplitude are gradually (or possibly abruptly) incremented with test data analysis occurring between increments. The abrupt accelerations (i.e., both spin and vibration) will seek to explore the non-linear effects of the far-from-equilibrium physics which ensue.

The testing to be evaluated in the one-year feasibility study includes an electrically charged test object (i.e., notionally 1-foot diameter and 1/8 to 1/4 inch thickness) in the shape of an aluminum disc (i.e., domed disc) or hollow cone that will be axially spun at rotational speeds up to 10,000 RPM. While higher speeds are desirable to achieve the predicted results, the physics can be confirmed at lower speeds that are within the test capabilities of AIR 4.4. Ultimately, the goal is to vibrate the test object, possibly by use of the piezoelectric effect by mounting lead zirconate titanate (PZT) modules circumferentially in a cruciform configuration on the underside of the test article. These PZT modules are vibrated by DC voltage (up to 1,000 Volts) applied to them from the same power source which electrifies the outside surface area (only) of the test object. Vibration frequencies (preferably from a "new" physics viewpoint) should be in the range of 10^5 Hertz (Hz) to 10^9 Hz, with vibration amplitudes of 0.04 inch (1 mm).

For the potential baseline experiments, the PIs recommend testing with 2,000 RPM spin and 1,000 Hz vibration in order to verify Equation 2 (EM energy flux value) in the technical paper attached within the STAIRS project proposal. This is preferred from a safety and test measurement perspective. Also, the test asset can be tested with accelerated spin only or accelerated vibration only, resulting in uncoupled effects. The test object will be mounted in a vacuum chamber ideally evacuated at pressures on the order of 5×10^{-6} Torr (outer space) with a Faraday cage (possibly stainless steel) mounted around the test device for safety of operation. The test object will be mounted to a hollow shaft with slip rings providing power to the PZTs. This will be a rotatable shaft connected to an electric motor via a gearbox which will control the acceleration of the test object's spin. An auxiliary device may act as a control device capable of accelerating and decelerating the PZT vibration.

It is of extreme importance to have the ability to control the accelerated modes of vibration and spin, in particular the rapid rates of change of accelerated-decelerated-accelerated vibration and/or accelerated-decelerated-accelerated gyration (i.e., axial spin) of the electrified test object. In this manner, we can delay the onset of relaxation to thermodynamic equilibrium, thus inducing a physical mechanism which may produce anomalies (such as inertial and gravitational mass reduction) due to the possible suppression (or reduction) of decoherence effects.

Research Justification

Explain why the proposed work constitutes basic or applied research.

This experimental investigation may prove fundamental in generating the high, electromagnetic, energy-flux values necessary to locally polarize the local Vacuum Energy State, thereby manipulating/modifying the local Spacetime, lattice-energy density. If we can engineer the metastructure of the local quantum vacuum state (the quantum vacuum has multiple structures), then we can engineer the fabric of our physical reality at the most fundamental level, and thus affect a physical system's inertial and gravitational properties. This realization would greatly advance the fields of aerospace propulsion and power generation, and eventually enable our dream of Interstellar Flight.

Refer to the technical paper titled "The High Energy Electromagnetic Field Generator" attached to the STAIRS project proposal for a more detailed description of the driving physics (i.e., S.C. Pais, The high energy electromagnetic field generator, Int. J. Space Science and Engineering, Vol.3, No. 4, 2015 pp.312-317; peer-reviewed).

Execution Plan

For each fiscal year, list each task, who performs the task, and break out the labor/ travel/ material costs. Explain travel costs that exceed $5k. In particular, explain reasoning behind laboratory support fees.

FY17:

- Create an Experiment within PSEF facilities capabilities:
  - **Task 1: Design of Experiment (DOE) (October 2016 - September 2017)**
    - Physicist (0.2 WY/348 hrs.); PI will be primary author of experiment
    - Mechanical Engineer, or ME (0.1 WY/174 hrs.); will provide major inputs interfacing with lab equipment
    - Test Facility Engineer (0.1 WY/174 hrs.); required as major contributor for lab equipment knowledge
  - **Task 2: Design the Test Asset(s) (October 2016 - February 2017)**
    - Physicist (0.05 WY/87 hrs.); supporting roll to evaluate trade space
    - ME (0.2 WY/348 hrs.); primary designer will interface with other MEs for expertise in loads, vibes, strength, etc.
  - **Task 3: Feasibility Study of Using, Mounting, and Powering PZTs on Test Asset (January - June 2017)**
    - Physicist (0.1 WY/174 hrs.); PI will be primary planner to achieve desired results from excitation
    - ME (0.1 WY/174 hrs.); primary designer will interface with test engineers and dynamic systems engineers to assess viability of system
    - Test Facility Engineer (0.05 WY/87 hrs.); required to inform integration decisions
  - **Task 4: Determine Electrical Power Requirements and Source Equipment (November 2016 - January 2017)**
    - Physicist (0.1 WY/174 hrs.); PI will detail calculated requirements
    - ME/Test Facility Engineer (0.05 MY/87 hrs.); consists of integration roll to determine need for and source new equipment as needed
  - **Task 5: Design/Source Instrumentation to Measure Anticipated Effects (February - June 2017)**
    - Physicist/ME (0.1 WY/174 hrs.); PI will detail calculated range of anticipated effects to be measured and work with lab instrumentation groups to determine need for additional equipment.

Technology Challenges

Describe the technical or scientific barrier, use metrics if applicable.

The primary technology challenge is the commercial-off-the-shelf (COTS) acquisition of PZT modules in the vibrational frequency range of 10^5 to 10^9 Hz, especially those on the high end of this frequency spectrum. However, this may not prove a barrier after all, since the experiment can still be performed at vibrational frequencies of approximately 10^5 Hz, as long as we do this at rapid rates of change of both coupled accelerated spin and accelerated vibration of the electrically-charged test asset (i.e., non-uniform accelerations). For our baseline experiments, we recommend testing with 2,000 RPM spin and 1,000 Hz vibration in order to verify Equation 2 (EM energy flux value) in the attached technical paper, as this is preferred from a safety and test measurement perspective. Also, the test asset can be tested with accelerated spin only or accelerated vibration only, resulting in uncoupled effects.

Make or Break Criteria

Describe the make or break exit criteria for each year.

FY17: The output of this one-year feasibility study should yield the completion of each of the five tasks shown in the Execution Plan (above), and should assess the feasibility and requirements (including costs) of conducting future work and experiments (FY18 and beyond) to test the hypothesis discussed in Section 3 (above) of generating and measuring high EM, field-intensity values.

If any step in the execution plan is deemed beyond 4.4 laboratory capabilities or anticipated budget allowances, the investigators will report findings through the leadership chain to determine a new course of action (COA). Possible new COAs could include continuing research in order to pursue cooperative agreements with DARPA, NRL, etc., or project stoppage and return or remaining project funds for this one-year effort.

Section 4 – NAWC / NAE Relevance / Benefit

Alignment

Alignment information below is for reference only. To modify alignments, use the Edit Proposal Alignment interface in STAIRS.

Competency core capability: Power and Energy Systems

Secondary core capability:

NAE Gap/STO: Strike Operations (STK) / STO-1: Responsive Engagement

Secondary NAE Gap/STO: Theater Air and Missile Defense (TAMD) / STO-2: Airborne Missile Defense

Counter IED: No

Overseas contingency operation: No

S&T research area: Power and Energy Technology

S&T research sub-area: Advanced Naval Power Systems

Key technologies: Physics / Electricity and Magnetism, Physics / Quantum Theory and Relativity, Power Production and Energy Conversion (Nonpropulsive) / Electric Power Production and Distribution, Propulsion, Engines and Fuels / Electric and Ion Propulsion

DoN S&T focus area(s): [Primary] Power & Energy / High Energy and Pulsed Power, Power & Energy / Efficient Power and Energy Systems

NAWC / NAE Benefit

Describe value to NAWC/ NAE and identify benefits to core capabilities/ S&T Objectives if successful. Describe any other anticipated benefits to the NAWC laboratory and/ or military capabilities.

The immediate benefit of this experimental work to NAWC/NAE is the development of novel/advanced High Density, High Power Systems, which is one of the core capabilities of the AIR 4.4 organization, under the Power and Energy systems umbrella. Furthermore, this project aligns well with one of the NAWCAD Technology Thrust Areas (viz., 5.0 Transformational Air Vehicle & Propulsion Concepts, in the sub-area of Increased Power Density). As such, these technologies could greatly enhance military capabilities.

Urgency

Describe why this research should be done now.

The results of these experiments can prove crucial for advancing the design of High Density / High Power systems concepts under the 4.4 Core Capability of Power and Energy Systems. If successful, this concept could ultimately be developed to greatly benefit the United States Warfighter in achieving battlefield supremacy, an endeavor of immediate importance and vital to our national security.

Research Products

Describe plans for potential publications/ presentations/ patent applications, etc. Also describe any workforce development impacts (i.e., employee mentoring/ summer students/ training, etc.) associated with this project.

Depending on the experimental results achieved from this effort, the PIs plan to possibly publish findings in AIAA or SAE technical journals. The PI is the author of Navy Case PAX 182, which has become U.S. Patent Application 14807943 entitled, "Electromagnetic Field Generator and Method to create Electromagnetic Field". Furthermore, I am also the author of Navy Case PAX 205 (The Inertial Mass Reduction Device) which has been recommended by Dr. James Sheehy (Chief Technology Officer) to become a patent application, and has recently been filed with the USPTO. Both these technical works are based on the physical mechanisms described in this proposal.

Section 5 – Project Transition

Transition Details

Transition information in the box below is for reference only. To modify this data, use the Edit Proposal Package Details interface in STAIRS.

Transition type: G - Product transitions to Naval Air Warfare Center / Fleet Readiness Center

Transition sponsor: AIR-4.0

Transition Sponsor Input

Has the transition sponsor provided input into this proposal? If yes, please describe the input provided.

No sponsor exists at this time.

Transition Plan

What is the next step for this research, if successful? Include any follow on plans for the transition of this technology if relevant (i.e. pursue other funding, etc.)

If this experiment is successful, the next step would be to build a device to harvest the energy created.

Section 6 – Related Projects

Related Projects

Identify any related S&T projects associated with this effort, including projects that contributed to, complement, or will be enhanced by this effort. Briefly summarize previous or current work performed in the area of this proposal, explain how the proposed work differs from other previous or ongoing projects.

None.

Section 7 – Collaborations

Collaborations

Identify any other individuals, teams or organizations collaborating on this project.

Academia: Possible correspondence with (b) (6) [redacted] (University of Puerto Rico) for exchange of ideas regarding present concept.

Government agency: Possible collaboration/correspondence with ONR, NRL, DARPA.

International: This concept may be ITAR restricted, especially any experimental results.

Private sector: Possibility exists, but not anticipated at the present time.

Tri-service: Possibility exists, but not anticipated at the present time.

Section 8 – Alternative Source Solicitation

Alternative Source Solicitation

Identify any other sources of funding you or your departments have solicited for this project - successful or unsuccessful.

None.

The High Energy Electromagnetic Field Generator

FY17 BAR/TT, Basic / Applied Research

FY2017 Cost Proposal

Labor

	Name	Code	GS/GSE	Hourly rate	% WY	# Hours	Est. cost
1.	(b) (6) [redacted]	4451	PAX - GS/GSE-13	$72.78/hr	50%	870	$63.32K
2.	(b) (6) [redacted] (Physisist)	4451	PAX - GS/GSE-13	$72.78/hr	50%	870	$63.32K
3.	Lab Technician	44	PAX - GS/GSE-13	$72.78/hr	20%	348	$25.33K
					Total labor costs:		$151.96K

Travel

There are no travel costs associated with this cost proposal.

Materials

There are no material costs associated with this cost proposal.

Total FY2017 proposal costs: $151.96K

COLLABORATIONS

There are currently no collaborations identified for this proposal.

FY2017 Cost Proposal Comments / Justification of Costs

There are no comments / justification of costs associated with this cost proposal.

12 MAY 2016

[redacted]

AIR 4.4.5

NISE BAR Selection Committee

Committee Members:

This letter is my endorsement of the FY17 NISE BAR Proposal, 'The High Energy Electromagnetic Field Generator', submitted by [redacted].

This basic research project explores the ability to produce exceptionally high electromagnetic field energy fluxes which is considered instrumental to designing advanced High Density, High Power Systems and significantly increasing future propulsion capability. The basic research project is an important first step toward developing advanced power and propulsion devices. The physics of this experiment have been peer reviewed and deemed sound.

The first year of this BAR proposal encompasses designing the test asset(s) and evaluating experimental conditions. This will determine the feasibility and effectiveness of the experiments. If viable, tests will be conducted in FY18 and provide valuable data in proving the physics needed to design completely new High Density, High Power Systems and Advanced Propulsion devices.

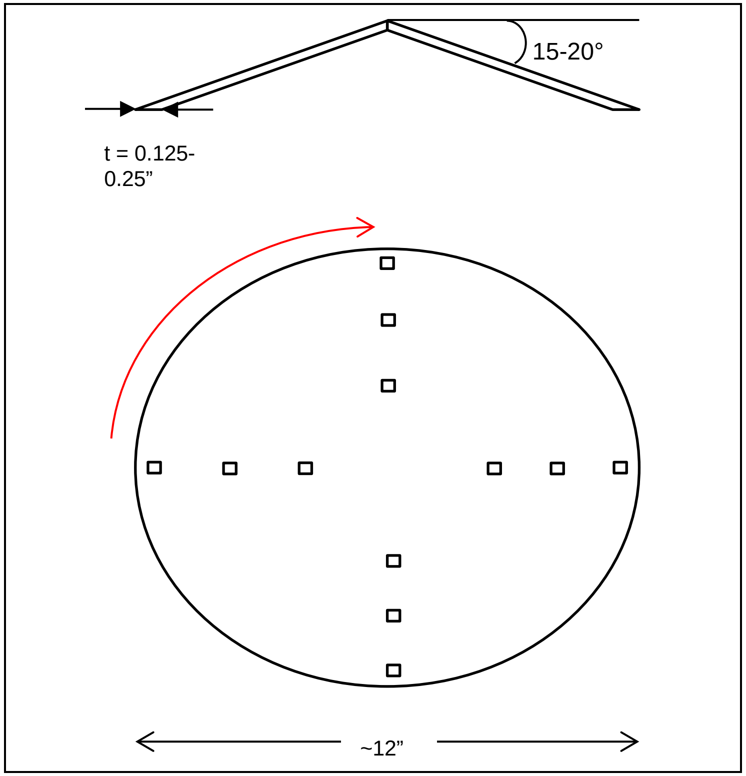
Thank you for your consideration.

[redacted]

AIR 4.4.5

The High Energy Electromagnetic Field Generator

Naval Innovative Science & Engineering (NISE) – Basic & Applied Research (BAR)



Key Performers / Teams:

Location: PAX River

PI: (b) (6) [redacted] 4.4.5.1, (b) (6) [redacted]

Assoc PI: (b) (6) [redacted], 4.4.5.1,
(b) (6) [redacted]

Objective/ Introduction:

- Conduct experiments to demonstrate high electromagnetic field energy flux values
- Successful demonstration contributes to the design of advanced High Density / High Power systems. No government proprietary information

Approach/ Method:

- Rotating the aluminum cone apparatus at 30k-100k RPM while inducing vibration at 10^5 Hertz to 10^9 Hertz, with vibration amplitudes of 0.04 inch is expected to produce high electromagnetic field energy flux values
- Milestones/Achievements
  - Design of the test apparatus and experiment
  - Conduct Experiment
  - Publish Results

DoD/ Naval Impacts/ Benefits:

- This experimental work develops the AIR 4.4 core capability of designing novel/advanced High Density, High Power Systems
- Applications of the anticipated results include next generation propulsion systems for all branches of the military which ensure the Unites States wins the future and achieves battlefield supremacy

Accomplishments/ Outcomes/ Potential:

- Publication in technical journal
- Navy Case PAX 182 (Electromagnetic Field Generator and Method to create Electromagnetic Field), applied for patent; Navy Case PAX 205 (The Inertial Mass Reduction Device), recommended for patent application

Test Plan Summary / NISE proposal – The High Energy Electromagnetic Field Generator

An electrically charged object (of 1 foot diameter, 1/8 inch to 1/4 inch thickness), in the shape of an aluminum disc (domed disc) or hollow cone, will be axially spun with rotational speeds of 1000 RPM to 10,000 RPM (in an accelerated mode). While it is being rotated the test object is being vibrated by use of the piezoelectric effect, in that lead zirconate titanate (PZT) modules are mounted circumferentially in a cruciform configuration on the underside of the domed disc / hollowed cone in question. These PZT modules are vibrated by DC voltage (up to 1000 Volts) applied to them from the same power source which electrifies the outside surface area (only) of the test object (the inside surface is electrically insulated). Given currently available PZT modules (COTS), vibration frequencies should be in the range of 10^3 Hertz to 10^5 Hertz (preferred), with vibration amplitudes of 1 millimeter (preferred). The vibration would be used as a perturbation to the non-linear far-from-equilibrium system generated by the accelerated spin of the electrically charged disc.

The test object is mounted in a vacuum chamber evacuated at pressures on the order of

500 mili-Torr (rotor spin facility – dictated).

A Faraday cage (possibly stainless steel) is mounted around the test device for safety of operation. The test object is welded to a hollow stainless steel shaft through which all the PZT electrode wiring will be routed. This is a rotatable shaft connected to an electric motor via a gearbox which controls the acceleration/deceleration of the test object's spin.

There is also some control device (drive), preferably manual in nature, which accelerates or decelerates the PZT vibration. Spin acceleration must have manual control as well.

It is of extreme importance that we have the ability to control the accelerated modes of vibration and spin, in particular the rapid rates of change of accelerated-decelerated-accelerated vibration and/or accelerated-decelerated-accelerated gyration (axial spin) of the electrified test object. In this manner we can delay the onset of relaxation to thermodynamic equilibrium, thus producing a physical mechanism which may induce anomalous effects.

Table 1: Test Conditions

Testing Measurands	**Baseline**	**Objective (Desired)**	**Available (Yes/No)**
Test Asset Configuration	Domed Disc	Cone	No (needs fabrication)
Polish of aluminum surface	Smooth (0.1 cm)	Rough surface	Yes
Thickness of test asset	1/4 “	1/8”	Yes
Diameter of test asset	12”	12”	Yes
Faraday cage	N/A	N/A	No (needs procurement)
Evacuated Chamber	0.1 Pa	0.001 Pa	No (not Vacuum desired)
EM Energy Flux detector	> 300 W/m^2	> 300 W/m^2	No (needs procurement)
Vibration acceleration Control	Max in 2 min.	Max in 2 min.	No (manual drive needed)
Spin acceleration Control	Max in 2 min.	Max in 2 min.	Yes (manual drive needed)
PZT Modules (Hertz)	1000	100,000	Yes
Test Asset Spin (RPM)	1000	10,000	Yes

<u>Test Notes:</u>

For our baseline experiments we recommend testing with 1000 RPM to 10,000 RPM accelerated spin and possibly 1000 Hertz vibration, to verify Equation 2, or any departures from it. (EM energy flux value in the attached technical paper). This is preferred from a safety and test measurement perspective. Also the test asset can be tested with accelerated spin only or accelerated vibration only, resulting in uncoupled effects.

The rest of the testing measurands would have to be generated from research performed during our FY17 Feasibility Study – from inputs given by 4.0 Physics/Structures/EMI/ Fuels SMEs.

NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION

PATUXENT RIVER, MARYLAND

TEST PLAN / TEST RESULTS

High Energy Electromagnetic Field Generation
Spin Test Experiment

NAVAIR 4.4.6.4
Propulsion & Power
Test Methods & Facilities Department

29 September 2019

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BACKGROUND

1. The Rotor Spin Facility (RSF) in the Propulsion System Evaluation Facility (PSEF) was requested to perform a spin test experiment on a charged disk test article to evaluate the concept of High Energy Electromagnetic Field Generation (HEEMFG). Salvatore Pais Ph.D. is the Principal Investigator (PI) for this experiment sponsored by the Naval Innovative Science & Engineering (NISE) program under the category of Basic & Applied Research (BAR). The concept of HEEMFG and its governing physics was proposed by Salvatore Pais Ph.D., AIR 4.3.5.1, in a paper titled “The high energy electromagnetic field generator” published in the International Journal of Space Science and Engineering, Vol.3, No. 4, 2015 pp.312-317.; this article is included in Appendix A.

2. The HEEMFG effect is described as very high energy electromagnetic field intensities resulting from accelerated spin of a highly charged (excess electrons) disk, in a vacuum, at high speeds, with acceleration transients and vibration. When put into practice, the HEEMFG effect could be used toward the design of advanced high energy density/ high power propulsion systems.

3. For quantitative detection of the HEEMFG effect, COTS sensors were considered to measure the frequency and calibrated amplitude of emitted electro-magnetic (EM) flux of the spinning charged disk; where ‘flux’ is power per unit area. COTS EM flux sensors operate over very narrow frequency bands and are directional in nature. Multiple COTS sensor systems would be needed to cover the wide 3 Hz to 3.2 GHz frequency band of interest. To reduce complexity and cost of the measurement, the team decided to design an EM flux detector with a single sensor covering the entire bandwidth of interest but with an un-calibrated relative amplitude output for qualitative only indication of the HEEMFG effect.

4. For the charged disk, initial efforts on this program focused on the design of a charged disk test article configured as a parallel plate capacitor capable of rotational speeds approaching 100,000 rpm but without a method for inducing disk vibration. A design using a ceramic dielectric sandwiched between two 3.25” diameter metal disks, incorporating a button cell battery to maintain the charge, was about 80% complete. Test spins on the button cell battery (.189” diameter) proved survivability at speed was acceptable (25 minutes at 100,000 rpm); however, the parallel plate capacitor design effort was suspended in preference to using a commercial off-the-shelf (COTS) coin cell capacitor (.276” diameter) with orders of magnitude greater charge carrying capability.

5. In September 2018, the HEEMFG Effect was evaluated by spinning three coin cell capacitors, each with 4 coulombs of charge, at speeds up to 100 krpm with acceleration rates up to 30 krpm/s and under vacuum level of .42 torr. The theoretical prediction by the PI for maximum EM flux intensity for a coin cell capacitor in non-accelerated spin at 4775 rpm (500 rad/s) in extreme proximity to the test article (~ 10^{-5} meters) is on the order of 10^{21} watts per meter squared; this is a maximum theoretical value without any experimental validation. The capacitor test vehicle and EM Flux detector/antenna performed well, but the HEEMFG Effect was not observed or disproved.

6. According to the PI, the HEEMFG theory requires the charge to be on the surface of the spinning disk. In the 2018 tested configuration, the distribution of charge in the capacitor was not known. Additionally, the PI emphasized that the HEEMFG effect is primarily a B-field (magnetic field) energy.

7. The current spin test effort will focus on changing the test configuration to ensure that the negative charge is on the surface of the spinning test disk. A charge level of 1 coulomb was the PI's requested target value.

PURPOSE AND OBJECTIVE OF TEST

8. The purpose of this test is to evaluate the presence of the HEEMFG effect resulting from spinning a disk with high negative surface charge (1 coulomb desired) to high speeds with rapid acceleration transients in a vacuum.

SCOPE OF TEST

9. The scope of the test program in Fiscal Year 2019 includes:

a) design of a spin test configuration that ensures charge is on the surface of the spinning test disk;

b) design improvements to increase B-field (magnetic field) sensitivity of the experimental EM Flux detector used for detection of the HEEMFG effect in the 2018 Coin Cell Capacitor test spin test; and

c) a spin test experiment to evaluate the HEEMFG effect.

10. The test configuration will use the vertical drive spindle (driveshaft) of the facility air motor to serve as the test disk and use high DC voltage to generate a charge on the surface of the spindle.

11. The HEEMFG Effect is presumed to emanate from the test disk as Radio Frequency wave energy or Electro-magnetic (EM) Flux (electric and magnetic fields). A qualitative measurement will be made using the experimental EM Flux Detector circuit that outputs a DC voltage proportional to relative amplitude (un-calibrated) for monitoring and recording. The HEEMFG Effect is indicated when a large amplitude increase in the EM Flux Detector output is observed relative to the baseline noise level.

12. The spin test to evaluate the HEEMFG Effect will spin the charged metal drive spindle to the speed versus time mission profiles supplied by the PI, shown in Figure 1 below. There are two profiles, one with low acceleration rates, up to 2000 rpm/s and one with high acceleration rates, up to 5000 rpm/s; the PI would like to see higher acceleration rates if possible.

Low Acceration			High Acceleration		
Elapsed time (sec)	RPM (Mission Low Accel.)	Acceleration (rpm/s)	Elapsed time (sec)	RPM (Mission High Accel.)	Acceleration (rpm/s)
0	0		0	0	
20	5,000	250	20	5,000	250
40	10,000	250	30	7,500	250
60	20,000	500	60	30,000	750
80	40,000	1,000	100	15,000	-375
100	80,000	2,000	120	55,000	2,000
120	100,000	1,000	150	80,000	833
140	100,000	0	200	60,000	-400
160	80,000	-1,000	220	100,000	2,000
180	40,000	-2,000	240	7,500	-4,625
200	20,000	-1,000	300	90,000	1,375
220	10,000	-500	320	5,000	-4,250
240	5,000	-250	340	100,000	4,750
260	0	-250	360	0	-5,000

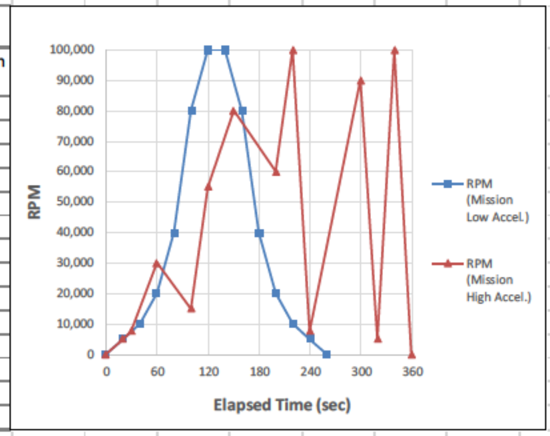

Figure 1 – Test Disk Mission Profiles

13. The drive spindle speed profiles will run under the following test conditions: spindle spinning in the clockwise direction (viewed from above), high DC voltage applied to charge the disk, spin chamber vacuum level of .5 torr or less, ambient temperature, and spindle radial displacement levels up to 25 mils Peak-to-Peak (PtP); spindle displacement typically includes sub-synchronous (~ 700 Hz +/-) whirl vibration component. Test conditions are summarized in Table 1 below.

Table 1 – HEEMFG Spin Test Conditions

Parameter	Test Condition
Speed Range	5000 rpm to 100,000 rpm
Over-speed SP: 0 – 70 krpm	70,500 rpm
Over-speed SP: 0 -100 krpm	102,000 rpm
Test Article Temperature	Ambient
Test Disk (Spindle) Charge	2.9 x 10E-8 Coulombs (custom straight Spindle)
High DC Voltage	43 kV
Spindle Speed Profile	See Figure 1
Chamber Vacuum	<500 mTorr (Best Achievable)
Test Article Vibration Limits	30 mils-PtP @ 0 rpm to 100,000 rpm
Direction of Rotation	Clockwise from above

14. The spin test experiment will include a series of test runs working up to the planned mission profile test runs. Individual test runs may need to be run multiple times to establish repeatability.

TEST SCHEDULE

15. The schedule is as follows:

Table 2 – Test Schedule

Task Description	**Timeframe**
EM flux Detection Instrumentation Develop/Design/Fabricate/Evaluate	April – June 2019
Tooling Design/Fabricate:	April - June 2019
Test Setup/Calibrations in Chamber #4	July/August 2019
Conduct Spin Test Experiment	**September 2019**
Report Results	September 2019

TEST TEAM

16. Core team members are given in Table 3 below.

Table 3 - HEEMFG Spin Test Team

Personnel	**Code**	**Position**	**Phone Number**
(b) (6) [redacted]	4.3.5.1	NISE Principal Investigator/Program Engineer	(b) (6) [redacted]
(b) (6) [redacted]	4.4.5.1	NISE Program Engineer	(b) (6) [redacted]
(b) (6) [redacted]	4.4.4.	NISE Program Engineer	(b) (6) [redacted]
(b) (6) [redacted]	4.4.6.4	Test & Evaluation Engineer	(b) (6) [redacted]
(b) (6) [redacted]	4.4.6.4	Test & Evaluation Engineer	(b) (6) [redacted]
(b) (6) [redacted]	4.4.6.3	Engineering Test Technician	(b) (6) [redacted]
(b) (6) [redacted]	4.4.6.5	Instrumentation	
(b) (6) [redacted]	4.4.6.5	Instrumentation	
(b) (6) [redacted]	4.4.6.5	Instrumentation	(b) (6) [redacted]
(b) (6) [redacted]	4.4.6.5	Instrumentation	

DESCRIPTION OF TEST FACILITY

17. The NAVAIR Rotor Spin Facility (RSF) is located within the Propulsion Systems Evaluation Facility (PSEF), building 2360, Patuxent River, MD. The RSF operates four above-ground vacuum spin chambers with inner diameters ranging from 24" to 106" designed to spin turbomachinery components up to design speeds to evaluate the structural and material aspects of rotating gas turbine engine components under simulated engine conditions. Spin tests are typically conducted in a vacuum to reduce the power required to drive the test article and to reduce the explosive hazards when testing at high temperatures. Spin testing always carries the risk of catastrophic failure of the component under test, so the spin chambers are designed to safely contain the release of high energy fragments; the safety containment features include thick annular steel rings for radial containment and a spin lid retention system for axial containment.

18. Barbour Stockwell, Inc. (BSI) vertical drive shaft air motors (or drive turbine) are used to drive the test rotors. The RSF has a range of air motors sizes, from 1.5” to 14”, to handle test articles up to 4000 lbs. and speeds up to 150,000 rpm and has the capability to conduct heated tests up to 2000 degrees Fahrenheit. The air motor and test rotor are assembled to a spin chamber lid in a separate build up shop and then transported by overhead crane to the spin chamber. Spin chambers are operated from a remotely located control room with independent controls and data acquisition for each chamber. Reinforced concrete walls separate the spin chamber from the buildup shop and control room for personnel safety. The spin test controls are set up to allow unmanned 24/7 automated cycling of test rotors and automatic shutdown of the test when test rotor or air motor health parameters exceed preset limits.

19. The RSF has three 2600 cfm compressors supplying compressed air to the air motors that drive the tests. Each chamber has a BSI model TC-4 automated speed controller that controls the supply of air to the air motor for cyclic or dwell control of test rotor speed. Each chamber has its own vacuum pump to evacuate the chamber with testing performed at best achievable vacuum below 1 torr, typically around 0.5 torr. Each chamber has a Pacific model 6000 data acquisition system for recording test rotor and facility parameter data, display of data for real-time monitoring, signal conditioning for the majority of parameters, and safety shutdown capability.

20. RSF has one APEX high speed data system capable of recording signals at 200 kHz sample rate with software for monitoring, recording and playback of the resulting large data files. ***The APEX system will be used to record the EM flux Detector output signal for primary indication of the HEEMFG Effect.***

DESCRIPTION OF TEST CONFIGURATION CONCEPT

21. The vertical drive spindle (driveshaft) of the spin facility's air motor serves as the test disk; specifically, the last approximately ½" of the 5/16" diameter spindle that extends into the vacuum spin chamber.

22. A high DC voltage is used to pull charge (excess electrons) to the surface of the rotating spindle and maintain the charge when the spindle is rotating. To do this, a stationary cylindrical iron core surrounds the test disk spindle (solid cylinder) separated by a cylindrical cross-section of dielectric material. A high voltage connected across the iron core and spindle forms a capacitive circuit; the iron core connects to the positive (+) side and the spindle to the negative (-) side of a high DC voltage power supply. The electric field developed between the iron core and spindle develops charge (excess electrons) on the spindle where the iron core overlaps the spindle's surface. The higher the voltage, the higher the charge. The voltage is kept below the breakdown voltage of the dielectric material to avoid an electrical discharge or arc into the iron core damaging the dielectric material.

23. The breakdown voltage for air under spin chamber vacuum conditions of .4 Torr is about 3.8 kV (kilovolt) per inch of air gap. A .09 inch radial thickness dielectric material with a dielectric strength of 500 kV per inch of thickness has a breakdown voltage value of 45 kV.

24. The amount of charge on the spindle is a function of voltage, dielectric strength, and the amount of spindle surface area overlapped by the iron core. The capacitive circuit formed by the iron core, dielectric material, and spindle concentric cylinders, including the air gap clearances in between, is modelled as a multiple dielectric cylinder capacitor. A charge level of 2.9x10E-08 coulombs is estimated for the custom spindle that extends .41" into the Iron Core. The radial air gap clearance between spindle and dielectric material is .06"; the radial air gap clearance between dielectric material and iron core is .163". Detailed calculation of the spindle charge level is given in Appendix B.

25. The HEEMFG Effect is enabled by rotating the spindle through various speed profiles with a surface charge on the spindle.

26. The HEEMFG Effect is presumed to occur in the form of RF waves (electric and magnetic) emanating from the test disk (Spindle). This electro-magnetic (EM) flux will be sensed by a coil style antenna mounted as close as possible to the iron core and spindle but far enough away to prevent arcing.

27. A corona discharge between the positively (+) charged iron core and the nearby negatively (-) charged spin chamber surfaces is expected to occur at some voltage below the breakdown voltage of the dielectric material. A corona discharge will be sensed by the EM Flux Detector circuit increasing the baseline noise level of the EM Flux Detector output; sensing of corona discharge will be used as an indication that high voltage has been applied to the iron core and the high voltage power supply is operational.

DESCRIPTION OF INSTALLATION AND TEST EQUIPMENT

Test Setup

28. The test setup is shown in Figures 3 and 4 below. The test will be performed in RSF spin chamber #4 located in PSEF room 72 and operated remotely from the control room (PSEF room 81). It consists of an air motor with integral drive spindle, spin lid, and vacuum chamber with internal lead brick lined steel containment ring.

29. A small high speed air motor powered by compressed air drives the spindle up to rotational speeds of 105,000 rpm. The air motor's 5/16" diameter vertical drive spindle extends down through the spin lid into the vacuum chamber. The Air Motor's turbine rotor shaft is supported in two, electrically non-conductive, ceramic bearings and held in place axially with a rotor locknut. Rotational speed is measured with a hall-effect style speed probe reading six teeth on the rotor locknut. A Spindle Nut connects the top of the Spindle to the rotor. The spindle is constrained in the radial direction at the top end, but the bottom end in the spin chamber is free to move in the radial direction. A squeeze film Damper section provides damping to the rotating spindle.

30. One proximity probe is used to monitor radial displacement (wobble) 1 inch from the end of the Spindle. During tests where the HEEMFG effect will be enabled, the proximity probe will be powered off and the lead end stowed in an electrically grounded metal box to prevent electromagnetic interference (EMI).

31. The Iron Core mounts inside the Dielectric Insulator, held captive with two plastic bolts and washers. The Dielectric Insulator mounts to the rig via a metal Adapter Plate which is bolted to the Proximity Probe Mount. The Dielectric Insulator provides the dielectric for the Iron Core/Spindle capacitive circuit. Its one-piece design is shaped to increase the arc path length between the Iron Core and nearby electrically grounded conductive surfaces to prevent arcing. The shortest arc path to ground is between the Iron Core and the metal Adapter Plate at 14.5" requiring 55 kV at the Iron Core for arcing to occur.

32. The Dielectric Insulator is .09" radial thickness where it passes through the Iron Core; the .09" thickness provides for a 45 kV breakdown voltage which should prevent arcing through this material when 43kV is applied to the Iron Core to charge the Spindle. There is a .06" radial air gap between the Spindle and Dielectric Insulator to allow clearance for the Spindle rotation and lateral motion due to whirl vibration. The radial air gap clearance between Dielectric Insulator and the Iron Core is .163".

33. A High Voltage DC Power Supply provides up to positive (+) 43 kVDC to the Iron Core. The power supply negative (-) lead is connected to earth ground. A stationary spring loaded Grounding Brush makes contact with the top of the rotating spindle; this electrically connects the spindle to earth ground completing the high voltage circuit with the Iron Core. An instrumentation slip ring is not used to ground the spindle due to voltage, rotational speed, and acceleration limitations.

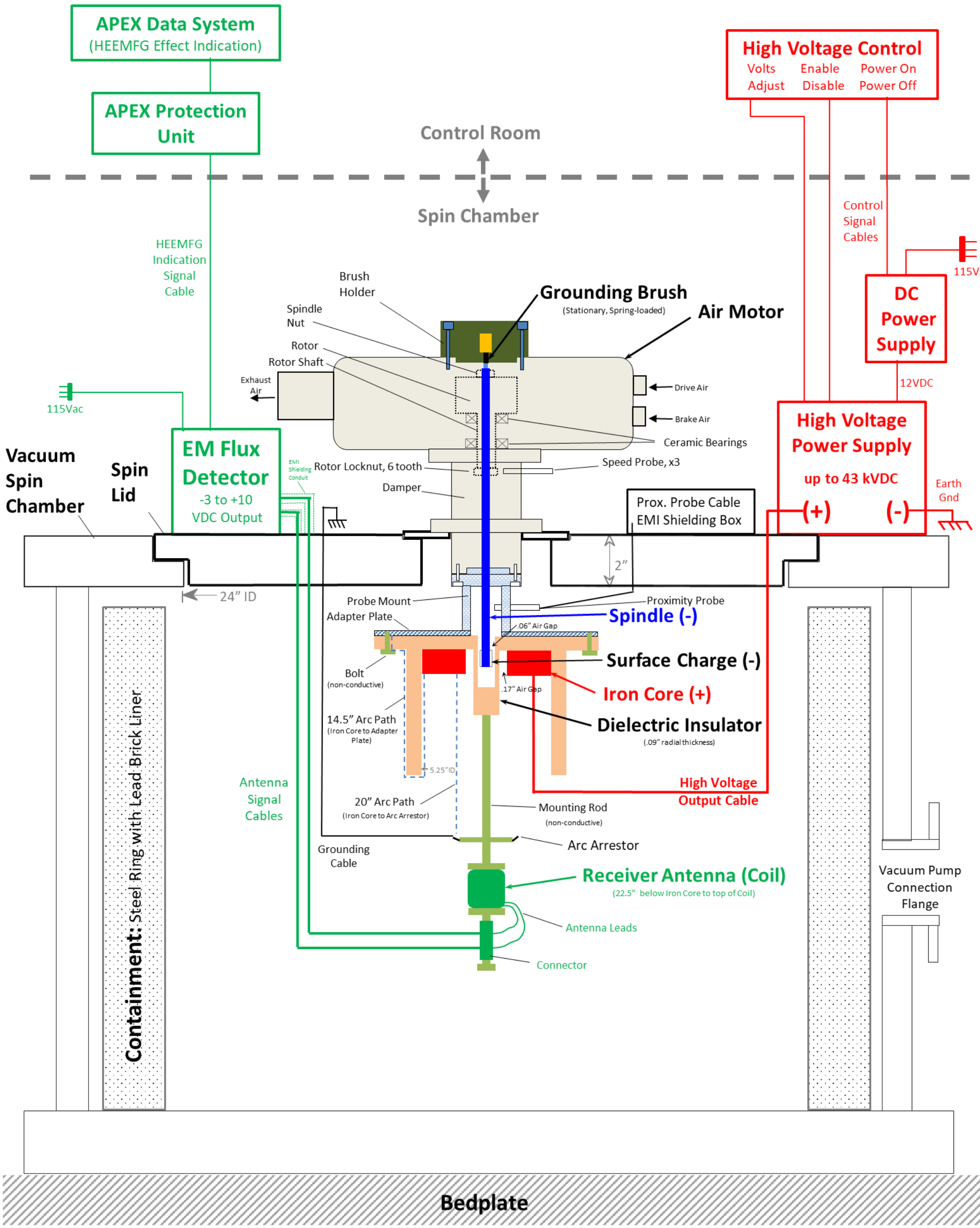

Figure 3. Spin Test Setup Diagram

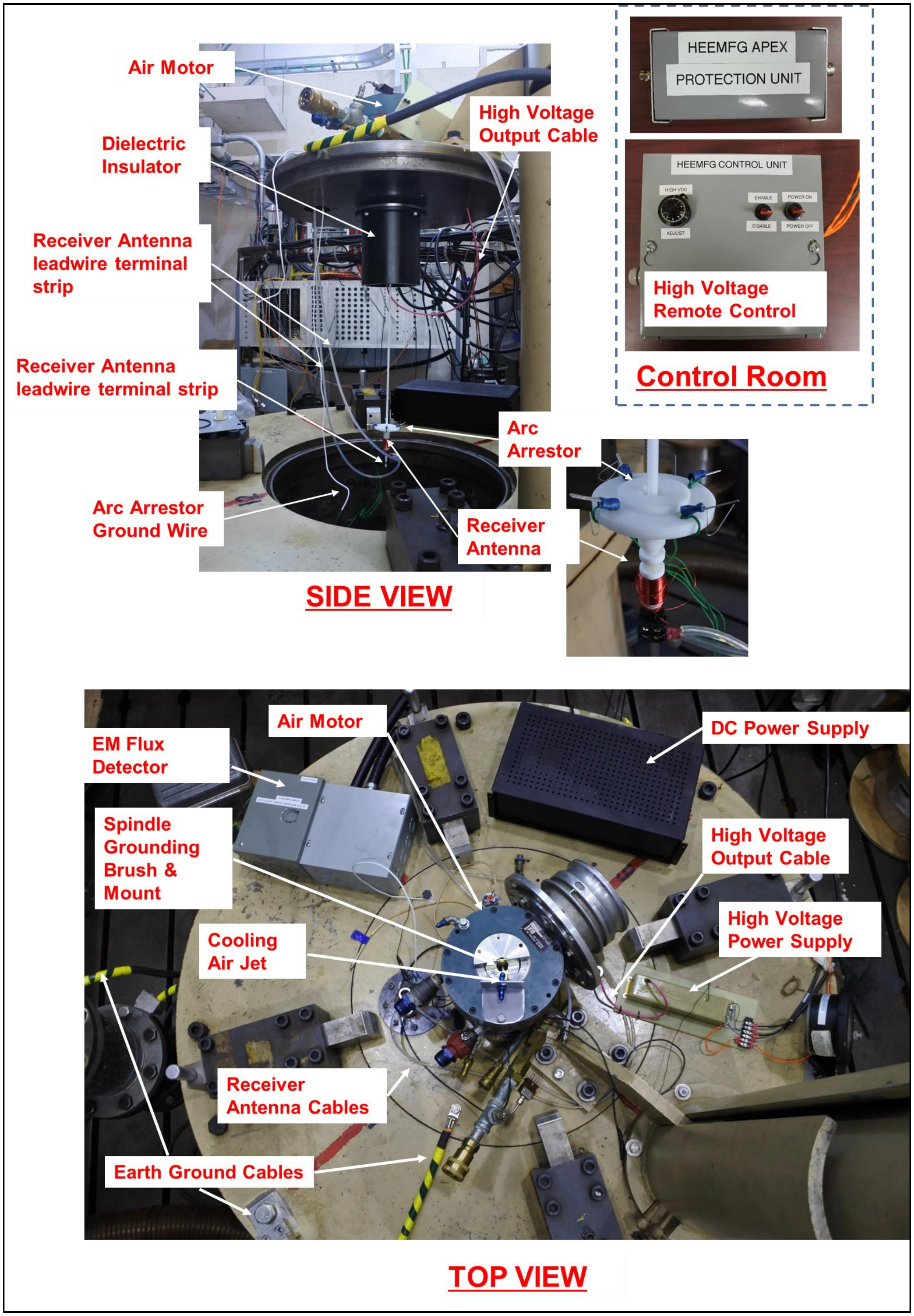

Figure 4. Spin Test Setup Photographs

34. The High Voltage Power Supply is powered by a separate 12 volt DC Power Supply box mounted outside the spin chamber. The DC power Supply box is powered by 115 Vac via corded plug. A High Voltage Controller box provides remote control of the High Power Supply from the control room; it provides for switched enable/disable function, switched power on/off function, and output voltage adjustment via a ten-turn pot.

35. The Spin Chamber, Spin Lid, Air Motor, Grounding Brush, Brush Mount, Spindle, Proximity Probe Mount, Adapter Plate, Arc Arrestor, vacuum pump piping/flanges connection, and spin chamber mounted instrumentation are all connected to earth ground so they are all at the same electrical potential of 0 volts.

36. Sensing of the HEEMFG Effect is accomplished with a wire-wound coil style receiver antenna inside the spin chamber, positioned directly below the Spindle. The top of the Antenna coil is 22.5" away from the Iron Core surface, far enough away to lower the risk of arcing to the Antenna. The Antenna's output signal is connected to the ungrounded (floating) input circuit of the EM flux Detector mounted outside the spin chamber. The EM Flux Detector is powered by 115 Vac via corded plug.

37. Arcing inside the vacuum spin chamber will damage the Antenna coil and the sensitive EM Flux Detector circuit, so to mitigate this risk, an Arc Arrestor is installed between the Iron Core and Antenna, 20" from the Iron Core. The Arc Arrestor utilizes "points" for protection, with minimal interference of any EM signal.

38. The Antenna and Arc Arrestor are suspended from the Dielectric Insulator using electrically insulating plastic ¼"-20 threaded rod and secured using plastic washers and nuts.

39. The EM Flux Detector's output signal is -10 to +10 VDC with baseline "zero" adjustment set to -3.0 VDC; the output is connected to an APEX high speed data system located in the control room via a 100+ feet of EMI shielded signal cable. An APEX Protection Unit provides overvoltage protection to the APEX's -10 to +10 VDC input. The APEX system is used to monitor and record, at 200 kilo-samples/sec, the EM Flux Detector's DC output signal for indication of the HEEMFG Effect. The Detector is designed to provide a DC output for EM detection; this is for detection beyond the Nyquist frequency which is 100 kHz with the APEX 200 kHz sample rate. Each conductor external to the chamber is run through grounded metal conduit for EMI protection.

40. There are a total of five (5) cable penetrations in the spin lid: one high voltage cable connecting the high voltage power supply output to the Iron Core; two antenna high voltage wires that connect to the EM Flux Detector to the Receiver Antenna leads; one proximity probe cable; and one cable connecting the Arc Arrestor to earth ground. The cables penetrate the spin lid using rubber grommet style compression fittings.

41. The all metal spin chamber entirely encloses the test disk and acts as a faraday cage to shield the test setup from unwanted external electromagnetic interference (EMI or noise) that could interfere with the EM flux measurement and/or cause a false positive indication and keep any potential radiation generated by the HEEMFG effect inside the chamber.

Test Specific Hardware

42. Custom hardware designed or procured specifically for this test setup are described below. See Appendix B for hardware drawings.

43. *Spindle (Custom)*: This part was manufactured from a BSI model 2529-B solid steel vertical drive spindle blank (5/16” dia.). The spindle driven-end has the standard ¼” square drive and ¼”-28 threaded feature for connection to the air motor’s turbine rotor. A precision .18” diameter by .18” tall extension was added to the top of the spindle to provide a precision surface for the graphite grounding brush to contact axially on the top of the spindle.

44. *Spindle (Standard)*: This standard solid steel vertical drive spindle is BSI model 2529R. The spindle driven-end has the standard ¼” square drive and ¼”-28 threaded feature for connection to the air motor’s turbine rotor. The machined finish at the spindle’s ends varies depending on the batch of spindles received; some spindles have machined centers on each end which is not suitable for contact with the grounding brush while others have a ground surface that may be flat enough to provide a precision surface for the graphite grounding brush to contact axially on the top of the spindle.

45. *Dielectric Insulator:* Custom one-piece plastic part machined from a single billet of Acetal Copolymer. This provides the dielectric in the annulus between the iron core and spindle. Its nominal dielectric strength is 500 kV per inch of thickness. The radial thickness is .090” which provides a nominal dielectric breakdown voltage of 45 kV. It is bolted to the Adapter Plate using plastic electrically insulating ¼-20 screws. It is designed as one piece to increase the air prevent the positively charged iron core from arcing to the spindle through the dielectric material or to nearby metal surfaces such as the spin chamber or Adapter Plate through the air path.

46. *Iron Core:* Custom cylindrically shaped iron part with dimensions of 3.9 OD x .938 ID x .762 tall inches. Mounts with clearance fits to inside of Dielectric Insulator using two electrically insulating plastic ¼-20 screws and plastic washers. The Iron Core is connected to the (+) high voltage lead of the High DC Voltage Power Supply using a ¼”-20 screw.

47. *Adapter Plate:* Custom steel adapter plate for mounting of Dielectric Insulator. Mounts to underside of Proximity Probe Mount with four low profile socket head cap screws.

48. *Probe Mount:* Custom aluminum mount to hold the proximity probes. Mounts to and pilots on the air motor damper section with four socket head cap screws.

49. *Grounding Brush Mount*: Custom aluminum mount that installs onto the top of the air motor to position a grounding brush for axial contact with the top of rotating spindle. It installs with two #8-32x5/8” socket head cap screws.

50. *__Grounding Brush:__* The grounding brush provides for electrical grounding of the rotating spindle. It is a small spring loaded graphite brush, 1/8" x 3/16", mounted in a .75 x .75 inch metal holder. It is mounted to the Grounding Brush Mount using a #4-40 UNF screw for axial contact of the top surface of the spindle. **The brush is adjusted so it contacts top of spindle and .090" to .125" from its metal holder**. The electrical path to ground is through the frame of the brush into the mounting screw, into the Grounding Brush Mount, into the Air Motor, and then into the Spin Lid earth ground connection. No lubrication is required. It is commercially available as Helwig Carbon Bearing Protector Kit BPK-IM2. Air cooling of the brush is not necessary according to the manufacturer; however, as added insurance against mechanical failure, a jet of compressed air will be directed at the brush/spindle contact to dissipate heat; this is not shown in the Figure 3 test setup diagram.

51. *__Grounding Cables:__* Size 000 copper wire used to connect the spin lid, spin chamber, and connected vacuum pump piping to earth ground and instrumentation ground. These ground connections provide EMI protection of the measurement and shock hazard safety for personnel.

52. *__Proximity Probe EMI Shielding Box:__* Metal box tied to earth ground for shielding the end of the proximity probe cable when not in use.

High DC Voltage Instrumentation

53. Test specific custom designed and manufactured high voltage instrumentation is described below. See Appendix C for electrical diagrams.

54. *__High Voltage Power Supply__:* An Ultra Volt Inc. model 40A12-P4-F-M-C-Y20-48-P2 high voltage DC-DC converter provides up to +43 kVdc positive (+) to the Iron Core. This is a low output power component made for space applications and is customized with the following features: A series, +40kVdc, 4 Watt, with Ripple Stripper Filter, high voltage lead 48" cable, Six-sided Mu-Metal Shield, with RF tight aluminum enclosure, and epoxy potting overflow to eliminate voids. It is mounted outside the spin chamber on the spin chamber lid with the insulated high voltage lead routed to inside the chamber through an electrically insulated chamber lid penetration. Output voltage is controlled through an external 0 to 5 Volt DC input signal corresponding to a 0 to 107.5% of rated volts output or 0 to 43 kV. The High Voltage Power Supply requires 12 VDC power.

55. *__DC Power Supply__:* This is a custom power supply to provide 12 volts DC power to the High Voltage DC Power Supply. It is located on the chamber 4 spin lid. It requires 115 Vac power. It has internal filters to clean up any voltage ripple to ensure the output is pure DC.

56. *__High Voltage Controller__:* This is a custom control box for remote control of the High Voltage DC Power Supply. It provides for switched enable/disable function, switched power on/off function, and output voltage adjustment via a ten-turn pot. The controller box provides on/off function by switching the DC Power Supply 12 VDC output on or off; it provides enable/disable and voltage output functions through direct cable connections to the High Voltage Power Supply. Voltage adjustment on this controller outputs a 0 - 5 VDC signal to adjust the voltage output of the High Voltage Power Supply from 0 to 43 kV.

EM Flux (HEEMFG) Detection Instrumentation

57. Test specific HEEMFG detection instrumentation are described below. See Appendix C for instrument diagrams.

58. *Receiver Antenna:* The receiving antenna consists of a self-supporting wire wound coil with two 24" leads terminated on a terminal strip. It is constructed of six (6) layers of 30 AWG magnet wire with dimensions of 5/8" inside diameter x 1" tall. It is sensitive to radio frequency (RF) waves, both E-field (electric) and B-field (magnetic) waves.

59. *Arc Arrestor:* This device protects the Receiver Antenna from being damaged from an arc. It is mounted 2.5 inches above the top of the Receiver Antenna. It has four equally spaced radial conductive tips tied to earth ground to bleed off charge before it can arc to the Receiver Antenna with negligible attenuation of any EM wave.

60. *EM flux Detector:* This device is a custom signal detector circuit designed and fabricated by PSEF to provide an output signal for qualitative indication of the "HEEMFG Effect". The detector circuit converts the "HEEMFG Effect" ac voltage signal output of the radio frequency (RF) receiving antenna surrounding the test article to a voltage proportional to relative amplitude (un-calibrated) for monitoring and recording on the APEX high speed data system. The detector's input is floating and not electrically grounded. The detector's output is transitioned smoothly to a purely dc value above 100kHz for compatibility with the APEX data system. The signal is pure ac below 15kHz and a combination of ac riding on dc between 15kHz to 100kHz, then changes to DC for all frequencies above 100 kHz. It can detect continuous sinusoidal RF wave voltage signals over an ultra-wide sub 1 Hz to 4 GHz frequency band and RF wave bursts greater than .5 µsec in duration. The design intent is to have the EM flux detector output at least 2 volts dc for very low power level ac signals from the antenna, in the range of .1 to 50 milliwatts.

61. *EMI Cable Shield Tubing:* Flexible metal tubing slipped over the portion of the two Antenna cables outside of the spin chamber to provide EMI shielding of the Antenna cable signal.

62. *Antenna Cables:* Two flexible signal cables with thick insulation rated for 42 kV are used to connect the in chamber mounted Antenna's output signal to outside of chamber mounted EM Flux Detector's inputs. The high voltage rating for the insulation is needed to prevent arcing to this cable.

63. *EMI Shielded Signal Cable:* The signal for indication of the HEEMFG Effect travels from the EM flux detector located on spin chamber #4 (room 72) and the APEX high speed data system in the control room (room #81). The signal is transmitted in a single run of about 125 ft. of Belden 9841, 2 conductor twisted shielded pair, 24 AWG size, stranded cable routed inside EMI shielding flexible conduit. These shielding precautions ensure EMI does not interfere with the EM flux detector's output causing false positive indications of the HEEMFG effect. Conduit shielding ground is connected to the spin chamber.

64. *APEX High Speed Data Acquisition System:* will record the EM flux detector output signal for primary indication of the presence of the HEEMFG Effect. This system is used for its high sample rate and ease of storing and viewing large data files. The system will be set to record at its maximum sample rate of 200k samples/sec (1 sample every 5 µsec). The APEX system will record EM Flux relative amplitude as a DC

voltage versus time. The system can only resolve the frequency of EM flux signals below 100 kHz; above 100 kHz, only relative amplitude without frequency information is indicated.

65. *APEX Protection Unit:* Custom protection circuit to provide overvoltage protection to the APEX system. It is inserted in the EM Flux Detection output signal cable at the input to the APEX system.

66. *Signal Generators:* Two signal generators are used to supply simulated signals during bench testing of the EM flux detector and antenna performance over the very wide 3 Hz to 3.2 GHz frequency band of interest. For low frequencies, an Agilent model 33220A 20 MHz Function/Arbitrary Waveform Generator will be used. An Agilent model 8648D 9kHz – 4000 MHz Signal Generator has been rented for $310/month to cover the high frequency requirements.

67. *Oscilloscope:* A Tektronix model TDS 2014C Digital Storage O-scope, 100 MHz, 2GS/s will be used to measure the output signal of the EM Flux Detector/Antenna during bench testing.

Test Equipment

68. The facility test equipment required to run the test is described below:

69. *Vacuum Spin Chamber #4* is a nominal 59” OD x 41” tall overall steel vacuum chamber located in PSEF test room #72. Chamber #4 is the smallest of the four spin chambers with usable inside dimensions of 24” inch diameter opening by 37 inch vertical depth. The pressure wall is 1” thick.

70. *Spin Chamber Lid:* The air motor is mounted to the top side of the spin chamber lid and has a 5” diameter center hole for passage of the vertical drive spindle. An integral hydraulic lift makes spin lid removal and access to the test vehicle quick and convenient as the overhead crane is not required. The spin lid and air motor assembly can be raised, lowered, and swiveled 180° to facilitate test article installation and inspections.

71. *Safety Radial Containment:* Permanently installed 4 inch radial thickness lead bricks inside of a 4 inch radial thickness steel ring provide containment of high speed rotor fragments in the radial direction should the test rotor fail catastrophically.

72. *Air Motor:* Barbour Stockwell Inc. (BSI) 2” model 7890 air motor with a standard damper section is used to drive the test article via a 5/16” OD custom drive spindle. Air motor peak power output is about 11 KW (90 psig air supply). The air motor’s turbine rotor is supported in two ceramic bearings and transmits torque to the spindle via a ¼” square drive. A ¼”-28 locknut secures the spindle axially to the rotor. The damper section has a squeeze film style damper, with spring loaded oil cups, to reduce lateral vibrations in the spindle. The facility owns two.

73. *Air Compressor:* Supplies compressed air to power the 2” air motor that drives the test vehicle. RSF has three centrifugal compressors available for spin testing, each can generate 2600 SCFM @ up to 140 psig. About 10% capacity of one compressor is sufficient for this test.

74. *Drive System Speed Control:* Air motor speed control is handled by a Barbour Stockwell TC4 cycle controller in conjunction with the SPIN IV software. Using the speed signal (6 per revolution) as feedback, the TC4 controls the flow of compressed air supplied to the drive and brake portions of the 2” air motor to accelerate and decelerate the test vehicle under automatic control to run the programmed mission cycle profile specified for the test. The air motor can also be operated with in full manual control of the supply, drive, and brake air valves.

75. *Air Supply Valves:* Compressed air from the facility 3” supply manifold is regulated through a 2” proportional valve and supplied to the air motor; it is distributed via 2” plumbing through two 3” fast acting butterfly valves that provide on/off control of the air flow through 1” hoses connected to the brake and drive portions of the air motor. Control air for the valves is sourced from PSEF shop air supply which is instrument grade dry air.

76. *Lubrication System:* An external oil lubrication cart is used to supply SHC-824 lubrication oil to the bearings and damper section of the drive turbine. In the event of a power outage, oil pumps are powered by a backup generator and/or compressed air driven motor.

Vacuum System: The test cell housing spin chamber #4 is equipped with one Kinney model KT300 vacuum pump with KMBD850 vacuum booster to evacuate the chamber. It is used to evacuate the test chamber to a vacuum level below 1 Torr.

Facility Instrumentation and Data Acquisition

77. General instrumentation and data acquisition systems required to run the test are described below.

78. *Rotational Speed Measurement:* Rotational speed is measured using the 6 pulse per revolution output of a hall-effect sensor reading the air motor’s 6 toothed rotor locknut. There are three sensors installed in 1/4"-40 threaded ports in the damper section of the air motor; they are spaced at 0° (OEM port), 120°, and 220°. The sensor gap should be set to .035 to .040. The sensors are SPECTEC model 0165A-73102 (or the 12" lead wire version 0165A-03C or alternatively a Barbour Stockwell model T-C-3-45); SPECTEC sensor is NPN w/internal 3k Ohm pull-up, normally high. The sensor’s raw pulsed signal is converted to rotational speed by a tachometer, Red Lion model RLC462-ND frequency to analog converter, and output as a 4-20ma analog signal for distribution to the data acquisition systems. The raw speed signal is also sent to the console Panel Tach. Based on testing of the speed measurement system with a function generator to simulate rpm, accuracy of speed indication begins to degrade during rpm ramp rates above +/- 30 krpm/s.

79. *Spindle Radial Displacement Measurement:* Radial displacement (wobble) of the drive spindle is monitored using one eddy-current *proximity probe* mounted axially positioned about 1” axially above the end of the spindle. The sensor is an SKF model CMSS65 probe with ¼”-28 x 1.2” threaded barrel, a 5 meter system length, a model CMSS665 driver, and sensitivity of 200 mv/mil. The sensor is gapped at .05” from the spindle. The raw output signal is converted to a 4 to 20 milliamp analog signal proportional to peak-to-peak displacement using a vibration transmitter, STI Vibration Monitoring Inc., model CMCP540-200-MOD3X; this transmitter is a special version designed to provide a ripple free output above 500 rpm. This displacement signal is used to trigger an automatic test shutdown when a threshold value is

exceeded. **The proximity probe is powered off during EM flux measurement runs to prevent electro-magnetic interference (EMI)**; **additionally, the probe lead end outside the spin chamber will be disconnected and stowed inside an EMI shielding box mounted on the spin lid**. .

80. *Data Acquisition and Signal Conditioning System: A* Pacific Instruments model 6000 provides signal conditioning used for recording of data and to trigger safety shutdowns. The system's single scan mode will capture data parameters at a rate of 10 samples/sec per channel into an Excel readable text file. The data system will be set to record during all test activities when the rotor is spinning. A single text file will contain all the runs for a single test day; the test day date is embedded in the filename for easy identification. The data files are archived to the RSF share drive on a daily basis. Note that the sample rate on this system is not fast enough to register transient signals from the EM flux detector.

Strip Chart Recorder: An Astro-Med strip chart recorder provides a permanent paper record of test rotor running history for up to 16 parameters. This provides backup records in case of a Pacific system malfunction. Note that the sample rate on this system is not fast enough to register any transient pulses from the EM flux Detector.

METHOD OF TEST

81. The spin test will be conducted fully manned, one shift per day, to execute the test matrix given in Table 4 below; each test may need to be run multiple times to establish repeatability. Completing the test matrix will require 1 to 3 test days. Tests will be run with air motor running on compressed air sourced from PSEF's 120 psig shop air supply with the pressure regulated to below 40 psig for better control of the unloaded air motor. The Pacific system in single scan mode will record all the test runs for each day in a single date stamped text file. The APEX system will record individual test runs as separate data files with a date and sequential run number embedded in the filename.

82. Testing will be conducted in two parts as described in test run procedures below:

Test Run Procedures

83. *Part 1 - Air Motor Functional Checkout and Speed Controller Tuning:* The custom test Spindle will be run through various speed profiles over a running range of 0 to 70 krpm. For this testing, the Grounding Brush is removed, the Proximity Probe is powered on, and the Dielectric Insulator is removed. To keep the Antenna, Arc Arrestor, and Iron Core cable connections undisturbed during this testing, the Dielectric Insulator will be temporarily attached to the underside of the spin lid away from the Spindle. The air motor will be driven with 120 psig shop air (3/4" line) regulated to 5 to 25 psig to improve control by slowing air motor acceleration. Unregulated 120 psig shop air (3/4" line) will supply the air motor control valves: brake, drive, main, and the proportional valve.

84. Use the speed profiles given in Table 4 test matrix, tests 1 through 3, for air motor checkout. The objectives of test runs 1 through 3 are to a) perform a functional check out the control system; b) determine the amplitude and frequency (by observing FFT) of spindle radial displacement levels; c) determine pressure regulator and control valve settings required to achieve the mission profile acceleration rates, and d) tune the control system for the mission profiles. If problems are encountered

running the custom Spindle, testing will continue using a compatible standard spindle.   The cell will be prepared for testing using the pre-test checks procedure below.

Pre-test checks for Air Motor Checkout

1. Insure Strip Chart paper record in on.
2. Insure Single Scan data recording on the Pacific data system is on.
3. Insure Pacific data system display screens setup for data monitoring.
4. Insure APEX data system display is ready for data monitoring and recording with correct file header and run #.
5. Insure air motor supply air is sourced from pressure regulated shop air.
6. Insure air supply regulator at correct pressure setpoint (TBD).
7. Insure correct overspeed setpoint value of 70.5 krpm is programmed into tachometer.
8. Measure and record spindle axial TIR at spindle top, radial TIR at spindle top, and radial TIR at spindle bottom.
9. Remove Grounding Brush taking care not to drop #4-40 screw into the rotor.
10. Confirm there is no hardware left loose on top of the rotor.
11. Remove Dielectric Insulator and attach on underside of spin lid away from Spindle AND keep the rest of the under spin lid test configuration intact.
12. Confirm High Voltage Power Supply is unplugged.
13. Confirm EM Flux Detector is unplugged.
14. Test is ready to run.

85. <u>*Part 2*</u> *- Spin Test of Charged Test Spindle to Evaluate HEEMFG Effect:* Table 4 test matrix, tests 4 through 28, will rotate the test Spindle through various speed profiles working up to the mission cycle profiles given in Figure 1, to evaluate the HEEMFG Effect. Each speed profile is run two times. The first test runs are with an uncharged test Spindle to establish the baseline noise level measured by the EM Flux Detector. The second test runs have +43kV applied to the Iron Core to generate a charge on the Spindle. Large changes in the EM Flux Detector's output amplitude relative to the respective baseline that are repeatable may be an indication of the HEEMFG Effect. The APEX data system will be used to monitor and record the EM Flux Detector output.

86. The Spindle grounding method is an experimental setup. The Grounding Brush is well within its surface speed capability up to 100 krpm; however, there is no direct experience at high speeds. Skipping of the Brush at the contact surface at high speed is a possibility; intermittent contact would result in the EM Flux Detector giving a false indication of the HEEMFG Effect. A conservative approach will be taken by starting at low target rpm values and working up to the max speed of 100 krpm. The proximity probes will be powered off and the cable ends stowed in the spin lid mounted EMI shielding box.

87. A corona discharge between the positively (+) charged Iron Core and the nearby negatively (-) charged spin chamber surfaces is expected to occur when 43kV is applied. The corona discharge will be sensed by

the EM Flux Detector circuit increasing the baseline noise level of the EM Flux Detector output. This increase in baseline noise level is confirmation the high voltage power supply and EM Flux Detector are functioning. Keying the mic of a walkie-talkie in close proximity to the EM Flux Detector will cause its output to spike and is another method for confirming the EM Flux Detector is functioning.

88. **CAUTION: Energizing the Iron Core with high voltage creates a shock hazard to personnel.** The shock hazard is mitigated by insuring the High Voltage Power Supply is powered off AND the DC Power Supply's 115Vac is unplugged prior to working on the spin chamber lid.

89. Prior to testing, **assign one team member as the "High Voltage Boss"** to perform High Voltage Power Supply Energize and De-energize procedures for the day's testing.

90. The following procedures shall be used to mitigate the high voltage shock hazard whenever personnel are working around the spin chamber lid mounted hardware or instruments. Use the Pre-test procedures below to prepare the cell for testing.

High Voltage Power Supply - De-energize Procedure

1. Set High Voltage Controller switch to "Power Off".
2. Set High Voltage Controller switch to "Disable".
3. Set High Voltage Controller ten-turn pot to "0".
4. Remove 115Vac power from DC Power Supply.

Note: Steps 1-3 insure the High Voltage Power Supply is not energized when 115 Vac power is restored to the DC Power Supply *

High Voltage Power Supply - Energize Procedure

1. Confirm correct connections of High Voltage Controller cables to High Voltage Power Supply.
2. Insure High Voltage Controller switch set to "Power Off".
3. Insure High Voltage Controller switch set to "Disable".
4. Insure High Voltage Controller ten-turn pot set to "0".
5. Announce "Clear the cell for High Voltage Power Up".
6. Clear cell of personnel.
7. Plug in 115Vac power to local outlet.
8. Announce "High Voltage in cell".
9. High Voltage Power Supply can now be powered on remotely using High Voltage Controller.

Pre-test checks for Charged Test Spindle Spin Test

1. Insure Strip Chart paper record in on.
2. Insure Single Scan data recording on the Pacific data system is on.
3. Insure Pacific data system display screens setup for data monitoring.
4. Insure APEX data system display is ready for data monitoring and recording with correct file header and run #.
5. Insure air motor supply air is sourced from regulated shop air.
6. Insure air supply regulator at correct setpoint (TBD).

7. Insure correct overspeed setpoint value of 70.5 krpm is programmed into tachometer.
8. Confirm a team member has been assigned as the “High Voltage Boss” to perform High Voltage Power Supply Energize and De-energize procedures.
9. Confirm electrical Spindle continuity with earth ground;
10. Confirm High Voltage Power Supply negative (-) lead continuity with earth ground.
11. Confirm High Voltage Output Cable is securely connected to Iron Core.
12. Confirm Arc Arrestor is 20” from Iron Core.
13. Confirm Arc Arrestor ground wire continuity with earth ground.
14. Turn on Grounding Brush cooling air jet.
15. Test is ready to run.

Table 4. Test Matrix

Test#	Test Name	Speed Profile	Spindle	Grnd Brush	EM Flux Detector	Iron Core Voltage	Chamber Vacuum	Prox Probe	Grnd Brush Cooling air	Instructions
Air Motor Functional Checkout and Speed Controller Tuning - Dielectric Insulator removed, Prox Probe on, Grounding Brush removed										
1	Air Motor Checkout - stair steps	0 to 70 krpm in 10krpm steps, adjusting air supply from 5 psig	custom	out	off	off	<.5 torr	on	off	Air supply to air motor sourced from shop air with regulator
2	Air Motor Checkout - mission low sweep	2000 rpm/s: 0 to 70 krpm to 0	custom	out	off	off	<.5 torr	on	off	
3	Air Motor Checkout - mission high sweep	5000 rpm/s: 0 to 70 krpm to 0	custom	out	off	off	<.5 torr	on	off	
Spin Test of Charged Spindle to evaluate HEEMFG Effect - Target rpm = 20 krpm										
4	Baseline Noise at 0 kV - static	static	custom	in	on	0	<.5 torr	off/stowed	on	
5	Charged Spindle - static	static	custom	in	on	43 kV	<.5 torr	off/stowed	on	
6	Baseline Noise - mission low	mission low to Target rpm	custom	in	on	0	<.5 torr	off/stowed	on	inspect gnd brush
7	Charged Spindle - mission low	mission low to Target rpm	custom	in	on	43 kV	<.5 torr	off/stowed	on	inspect gnd brush
8	Baseline Noise - mission high	mission high to Target rpm	custom	in	on	0	<.5 torr	off/stowed	on	inspect gnd brush
9	Charged Spindle - mission high	mission high to Target rpm	custom	in	on	43 kV	<.5 torr	off/stowed	on	inspect gnd brush
Spin Test of Charged Spindle to evaluate HEEMFG Effect - Target rpm = 50 krpm										
10	Baseline Noise at 0 kV - static	static	custom	in	on	0	<.5 torr	off/stowed	on	
11	Charged Spindle - static	static	custom	in	on	43 kV	<.5 torr	off/stowed	on	
12	Baseline Noise - mission low	mission low to Target rpm	custom	in	on	0	<.5 torr	off/stowed	on	inspect gnd brush
13	Charged Spindle - mission low	mission low to Target rpm	custom	in	on	43 kV	<.5 torr	off/stowed	on	inspect gnd brush
14	Baseline Noise - mission high	mission high to Target rpm	custom	in	on	0	<.5 torr	off/stowed	on	inspect gnd brush
15	Charged Spindle - mission high	mission high to Target rpm	custom	in	on	43 kV	<.5 torr	off/stowed	on	inspect gnd brush
Spin Test of Charged Spindle to evaluate HEEMFG Effect - Target rpm = 70 krpm										
16	Baseline Noise at 0 kV - static	static	custom	in	on	0	<.5 torr	off/stowed	on	
17	Charged Spindle - static	static	custom	in	on	43 kV	<.5 torr	off/stowed	on	
18	Baseline Noise - mission low	mission low to Target rpm	custom	in	on	0	<.5 torr	off/stowed	on	inspect gnd brush
19	Charged Spindle - mission low	mission low to Target rpm	custom	in	on	43 kV	<.5 torr	off/stowed	on	inspect gnd brush
20	Baseline Noise - mission high	mission high to Target rpm	custom	in	on	0	<.5 torr	off/stowed	on	inspect gnd brush
21	Charged Spindle - mission high	mission high to Target rpm	custom	in	on	43 kV	<.5 torr	off/stowed	on	inspect gnd brush
Spin Test of Charged Spindle to evaluate HEEMFG Effect - Target rpm = 100 krpm										
22	Baseline Noise at 0 kV - static	static	custom	in	on	0	<.5 torr	off/stowed	on	
23	Charged Spindle - static	static	custom	in	on	43 kV	<.5 torr	off/stowed	on	
24	Baseline Noise - mission low	mission low to Target rpm	custom	in	on	0	<.5 torr	off/stowed	on	inspect gnd brush
25	Charged Spindle - mission low	mission low to Target rpm	custom	in	on	43 kV	<.5 torr	off/stowed	on	inspect gnd brush
26	Baseline Noise - mission high	mission high to Target rpm	custom	in	on	0	<.5 torr	off/stowed	on	inspect gnd brush
27	Charged Spindle - mission high	mission high to Target rpm	custom	in	on	43 kV	<.5 torr	off/stowed	on	inspect gnd brush
28	Charged Spindle - mission low - max accel	mission low to Target rpm with max accel/decel (up to 30 krpm/s) at speed setpoints	custom	in	on	43 kV	<.5 torr	off/stowed	on	inspect gnd brush

Test Operations

91. Test operations are covered by the Daily Checklist given in Appendix D and the Emergency Procedures found in Appendix E.

INSTRUMENTATION LIST

92. The list of instrumentation parameters and data system connections required for safe operation of the test is given in Table 5. All parameters are to be recorded at 10 samples/sec by the Pacific data system single scan feature. A subset of these parameters will be recorded on a paper chart recorder; the chart recorder configuration is given in Table 6. The EM Flux Detector output along with select parameters will be recorded by the APEX system at 200 ksamples/sec.

Table 5. Instrumentation List

HEEMFG Spin Test
Instrumentation Parameters List
(30 July 2019, rev. 1)

Description	Parameter Label	Measurement Range	Units	*Shutdown Limit S P.*	PACIFIC (10 Hz)	APEX (200 kHz)	Chart Recorder	Tach Display	BSI Control
SYSTEM TIME SYNC									
IRIG-B time sync	IRIG				X	X	X		
ROTATIONAL SPEED									
Speed at 0°	Speed1_(krpm)	0 - 110	krpm	*> 102*	X	X			X*
Speed at 120°	Speed2_(krpm)	0 - 110	krpm		X	X		X*	
Speed at 220°	Speed3_(krpm)	0 - 110	krpm		X	X			
DISPLACEMENT (VIBRATION)									
Spindle Displacement X	Disp_X_(mils-PtP)	0 - 50	mils_PtP	*> 30*	X	X	X		
Spindle Displacement Y	Disp_Y_(mils-PtP)	0 - 50	mils_PtP	*> 30*	X	X	X		
Spindle Displacement X raw	Disp_X_raw_(mils)	+ / - 25	mils		X*	X*			
Spindle Displacement Y raw	Disp_Y_raw_(mils)	+ / - 25	mils		X*	X*			
CHAMBER CONDITIONS									
Chamber Vacuum	Vacuum_(torr)	0 - 2	torr	*> 2*	X	X	X		
~~Chamber Air Temperature~~	~~T_ChamAir_(F)~~	~~0 - 200~~	~~°F~~	~~*>150*~~	~~X~~	~~X~~	~~X~~		
"HEEMFG EFFECT" SENSOR									
EM Field Flux Detector	**EMF_Flux_(V)**	**0 - 10**	**V**			**X**			
AIR MOTOR									
Supply Oil Temperature	T_SupplyOil_(F)	0 - 200	°F	*> 150*	X				
Return Oil Temperature	T_ReturnOil_ (F)	0 - 200	°F	*> 175*	X				
Bearing Oil Pressure	P_BrgOil_(psig)	0 - 50	psig	*<10*	X				
Damper Oil Pressure	P_DamperOil_(psig)	0 - 50	psig	*<10*	X				
Balance Air Pressure	P_BalAir_(psig)	0 - 50	psig		X				
Seal Air Pressure	P_SealAir_(psig)	0 - 50	psig		X				
Drive Air Pressure	P_DriveAir_(psig)	0 - 150	psig		X		X		
Brake Air Pressure	P_BrakeAir_(psig)	0 - 150	psig		X		X		
Supply Air Pressure	P_SupplyAir_(psig)	0 - 150	psig		X				
VACUUM PUMP									
Vacuum Pump Oil Temperature	T_VacPump_Oil_(F)	0 - 200	°F		X				
NOTES:									
X* indicates raw signal									

Table 6. Chart Recorder Setup

HEEMFG Spin Test
Chart Recorder Layout
(4 June 2018 rev.1)

Graph	Parameter	Display Range	Units	Unit Grad.	Text	Description	Graph Size
n/a	n/a: Label Header	n/a	n/a	n/a	"HEEMFG Spin Test "		n/a
n/a	n/a: IRIG	n/a	n/a	n/a	Time/Date on edge of strip chart	IRIG-B time code sync from Datum model 9300 Time Code Generator	n/a
1	Speed_(krpm)	0 - 110	krpm	2 2	*Speed_(krpm) 0 - 110*	Speed, median value from Speed 1, Speed2, and Speed3	1/4
2	~~EMF_Flux_(V)~~	~~0 - 10~~	~~krpm~~	~~0 2~~	~~*EMF_Flux_(V) 0 - 10*~~	~~EM Field Flux Detector Output~~	1/4
3	DISP_X_(mils-PtP) DISP_Y_(mils-PtP)	0 - 50 0 - 50	mils-PtP mils-PtP	1	*DISP_X_(mils-PtP) 0 - 50* *DISP_Y_(mils-PtP) 0 - 50*	Spindle X radial displacement ~ 1 25" from spindle end Spindle Y radial displacement ~ 1 25" from spindle end	1/8
4	Vacuum_(torr)	0 - 2	torr	0 04	*Vacuum_(torr) 0 - 2*	Chamber Vacuum	1/8
5	T_ChamAir_(F)	0 - 200	°F	4	*T_ChamAir_(F) 0 - 200*	Chamer Air Temperature measured near spindle	1/8
6	P_DriveAir_(psig) P_BrakeAir_(psig)	0 - 150 0 - 150	psig psig	3	*P_DriveAir_(psig) 0 - 150* *P_BrakeAir_(psig) 0 - 150*	Drive pressure measured at Air Motor port Brake pressure measured at Air Motor port	1/8

OPERATING LIMITS AND ALARMS

93. Operating limits for the air motor and drive spindle are given in Table 7 below.

Table 7. Operating Limits

Parameter	Limit
Rotational Speed (rpm)	105,000
Air Motor Damper Oil Pressure (psig)	< 10
Air Motor Bearing Oil Pressure (psig)	< 20
Air Motor Return Oil Temp (°F)	> 180
Vacuum (torr)	< 20
Drive Spindle Radial Displacement Sub-synchronous (mils P-P)	30
Drive Spindle Radial Displacement Synchronous(mils P-P)	3
Cycle Timer	disabled

DATA REDUCTION PROGRAMMING AND ANALYSIS

94. Data analysis consists of monitoring real-time display of the EM Flux Detector output and playback of the recorded to evaluate the presence of the HEEMFG Effect.

REPORTING REQUIREMENTS

95. The planned deliverable consists of *a summary report,* completed by the test engineer, describing the test methods and test results.

RISKS

96. The primary risks to testing are listed below:

a) Intermittent contact (skipping) of Grounding Brush with Spindle causing false positive indications of the HEEMFG Effect.

b) Mechanical failure or excessive wear of Grounding Brush prevents test completion.

c) Mechanical Oscillator Effect due to Spindle lateral motions causing false positive indications of the HEEMFG Effect.

TEST RESULTS

97. A charged disk, in the form of a vertical drive spindle, was spun in a vacuum spin chamber to evaluate the presence of the HEEMFG effect. The spin test was conducted in the RSF spin chamber 4 over four test days: 18, 19, 23, and 25 September 2019.

98. The HEEMFG effect is presumed to emanate from the spindle as RF wave energy. The HEEMFG effect is enabled by spinning the charged spindle to high speeds with rapid acceleration transients, in a vacuum. The Principle Investigator also desired vibratory excitation of the charged test disk (spindle); however, the tested configuration does not have a method for providing spindle vibration.

99. The spin test experiment was performed with the test setup configuration as shown in Figures 3 and 4. The test was conducted in two parts, loosely following the Table 4 test matrix. A 43 kV DC voltage was used to generate and maintain a 2.9 x 10E-08 coulomb surface charge on the end of the spindle that extends into the spin chamber. The spindle end outside of the spin chamber was electrically grounded using a stationary spring-loaded graphite brush; the brush was air cooled using a jet of dry compressed air.

100. Part 1 of the test matrix, Air Motor Checkout, was conducted on the 18th and 19th and recorded as APEX data system runs 600 through 613. The 3" air supply control valves and 3" air supply piping are sized for rapid cycling of the air motor to support typical spin chamber cyclic fatigue tests; this control setup coupled to an air motor with a very small rotor inertia - just a drive spindle – makes slow accel speed control difficult or impossible. The air motor checkout tests experimented with controlling the air motor with air supplied from the ¾" facility shop air supply line at reduced pressures to slow down air motor acceleration and provide better speed control. The best settings allowed speed control to begin at about 10 krpm. These tests determined that the automated speed control could not follow the desired mission low and mission high speed versus time profiles; a best effort manual control of the air valves to control speed was the only option. A speed control system software 'data record error' caused frequent test shutdowns, ramping the air motor speed to 0 rpm; no fix for this nuisance shutdown was available and persisted through all of the testing.

101. With the spindle installed in the air motor, the total indicated runout (radial) was 0.002 inches as measured with a dial indicator at the spindle end. Air motor operation and spindle rotor dynamics were confirmed stable up to 70 krpm. At speed, spindle radial displacement was synchronous (1 per revolution) up to about 40 krpm, with a peak of 11 mils-PtP (0.011 inch peak-to-peak) at 23 krpm, then it transitioned to all sub-synchronous whirl motion around 425 Hz with amplitude of 16 mils-PtP at 70 krpm. Spindle dynamics up to 100 krpm was captured during APEX run 745 on the 25th at the end of Part 2 testing; the spindle motion at 100 krpm was sub-synchronous at 470 Hz with an amplitude of 24 mils-PtP. The spindle dynamics was consistent with prior "spindle only running" experience.

102. Part 2 of the test matrix, Charged Spindle Tests to Evaluate the HEEMFG Effect, was conducted on the 23rd and 25th and recorded as APEX data system runs 700 through 745. The tests spun the charged spindle to a best effort replication of the mission low and mission high speed versus time profiles; the best effort manual speed control was generally able to replicate the high speed setpoints and dwell time, but not the acceleration and deceleration rates. Additional speed versus time profiles that the automatic control system could perform and repeat were performed; they included rapid saw-tooth shaped profiles and profiles with rapid snaps to high speeds followed by dwell time.

103. HEEMFG effect indication was given by a change in the EM Flux Detector's output during rotation of the charged spindle relative to the EM Flux Detector's baseline output for the uncharged spindle. The Detector outputs a -10 to +10 DC volt signal proportional to EM flux strength; the Detector's zero is adjustable and was set at a nominal value of -3.0 VDC for this testing. Prior to test start, Detector operation was verified by keying the transmit button on a walkie-talkie in close proximity to the Detector. This generated a pulse of about 2VDC above the Detector's baseline level which confirmed the Detector was working (run 700 and 719).

104. With the stationary spindle electrically grounded through the graphite brush, the iron core voltage was manually ramped up to 43 kVDC to charge the spindle; after some time, which can be tens of minutes, corona discharge develops inside the chamber and increases the baseline noise span from about .04 V to 0.2 V centered on the -3.1 VDC output. It was found in runs 706 through 708 that spinning an uncharged spindle did not change the Detector baseline noise level. Noise spikes of varying amplitude are

prevalent in the Detector baseline noise when the 43 kV is energized. The noise spikes are micro-arcs caused by the corona discharge; these noise spikes are ignored when interpreting changes in the Detector output for indications of the HEEMFG effect. Also ignored, is a noise spike that occurs when the 43kV power supply is turned on to charge the spindle.

105. Spindle rotation was not started until the Detector baseline noise caused by the corona discharge was fully developed and stabilized; the more time that elapsed between charged spindle runs, the longer it took. For some of the testing, the 43 kV remained on between test runs to minimize the time to fully develop the baseline level.

106. Figure 5 below is a screenshot of APEX data system run 739 which includes 10 rapid saw-tooth cycles, from low speed to 100 krpm and back to low speed, followed by 150 seconds of dwell time at 100 krpm with a charged spindle. Figure 5 is annotated to show the corona discharge noise on the Detector output, noise spikes from corona discharge micro-arcs, and to show the noise spike that occurs when the high voltage circuit is energized. There is no shift in the fully developed corona discharge noise when the charged spindle is spun through this aggressive speed profile; the interpretation is “No HEEMFG Observed”.

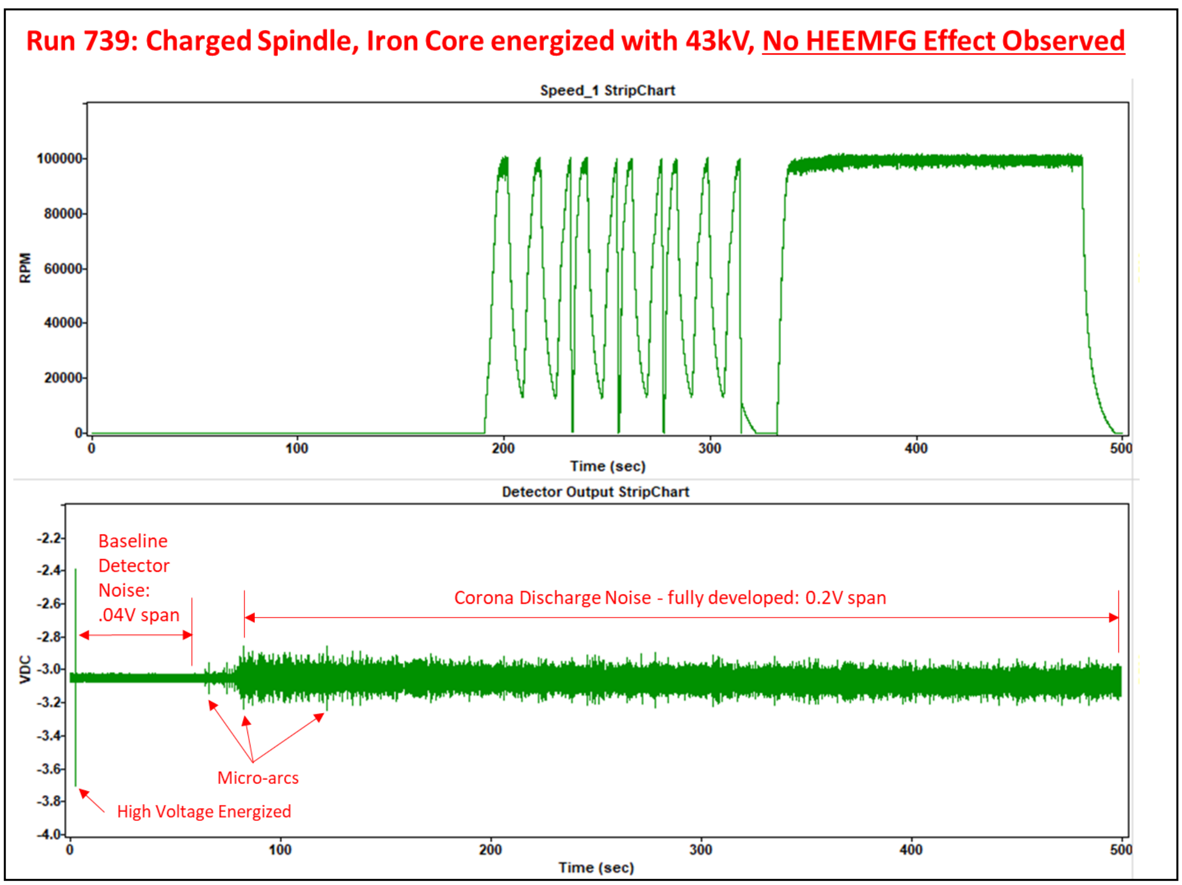

Figure 5. APEX Run 739

107. On two of the test runs, 711 and 712, the Detector output shifted by +0.1 and -0.1 volts, respectively, while the charged spindle was spinning; however, the shift persisted beyond the end of test run when the spindle was stationary. On both of these runs, multiple people reported feeling a mild sensation on their skin as they approached the spin chamber immediately after the run; the sensation was noticed as far as 10 feet from spin chamber, increasing in intensity near the spin chamber. The skin sensation and the 0.1-volt shift in the Detector output dissipated less than 10 minutes later. A 0.1 volt shift is small, but well within the measuring range of the Detector. For both runs, because the 0.1 volt shift in Detector output persisted after spindle rotation was stopped, the HEEMFG effect was not indicated. There are natural and manmade phenomena that can provide reasonable explanations for both the Detector output shift and the anomalous skin sensation experiences.

108. Test results are tabulated in Table 8 below. The HEEMFG effect result for each test run is given in the column labeled "Interpretation: HEEMFG effect Observed?". Out of the 46 separate test runs, 31 runs were used to evaluate the HEEMFG effect spinning the charged spindle through various speed versus time profiles. The HEEMFG effect was not observed on any of the test runs.

Table 8. HEEMFG Test Results

Start Time	**Run#**	**Iron Core Voltage**	**Test Name - speed profile**	**Speed Control**	**Detector DC Noise Level Span (VDC)**	**Shift in Detector DC Level (VDC)**	**DC Level Shift Interpretation: Effect Observed?**	**Comment**
			Monday 23 September 2019					
931	700	off	Detector ops check - static - mic keyed near detector		0	**1.9**	N/A	Detector working
1050	***Inspected Grounding Brush, spindle resistance to grnd is 6 ohms, cleaned with alcohol , spindle resistance to grnd 0.4 ohms***							
1134	701	off	Baseline noise level - static		0.04		N/A	
1139	702	43 kV	Baseline Charged Spindle - static		0.2		N/A	
1150	703	43 kV	Baseline Charged Spindle - static		0.2		N/A	
1225	705	43 kV	Baseline Charged Spindle - static, ramped 0-43kV-0		0.2		N/A	
1228	706	off	Baseline noise - bump to 11 krpm	Manual	0.04		N/A	
1318	707	off	Baseline noise - mission low to 20 krpm	Manual	0.04		N/A	
1326	708	off	Baseline noise - mission low to 20 krpm	Manual	0.04		N/A	
1335	709	**43 kV**	**Charged Spindle** - mission low to 20 krpm	Manual	0.2	0	**Not Observed**	
1347	710	**43 kV**	**Charged Spindle** - mission high to 20 krpm	Manual	0.2	0	**Not Observed**	
1356	711	**43 kV**	**Charged Spindle** - mission low to 70 krpm	Manual	0.2	**0.1**	**Not Observed**	Anomalous indication persisted after spindle stopped
1411	712	**43 kV**	**Charged Spindle** - mission low to 70 krpm	Manual	0.2	**-0.1**	**Not Observed**	Anomalous indication persisted after spindle stopped
1445	713	**43 kV**	**Charged Spindle** - mission low to 70 krpm	Manual	0.2	0	**Not Observed**	
1454	714	**43 kV**	**Charged Spindle** - mission low to 70 krpm	Manual	0.2	0	**Not Observed**	
1506	***Inspected Grounding Brush, spindle resistance to grnd is 6.7 ohms, cleaned with alcohol twice, spindle resistance to grnd 5 ohms***							
1528	715	**43 kV**	**Charged Spindle** - mission low to 70 krpm	Manual	0.2	0	**Not Observed**	
1535	716	**43 kV**	**Charged Spindle** - mission high to 70 krpm	Manual	0.2	0	**Not Observed**	
1543	717	**43 kV**	**Charged Spindle** - mission high to 70 krpm	Manual	0.2	0	**Not Observed**	
1600	***Inspected Grounding Brush, spindle resistance to grnd is 0.6 ohms***							
1609	718	43 kV	**Charged Spindle** - five snaps to 70 krpm	Manual	0.2	0	**Not Observed**	

Table 8 (continued). HEEMFG Test Results

Start Time	Run#	Iron Core Voltage	Test Name - speed profile	Speed Control	Detector DC Noise Level Span (VDC)	Shift in Detector DC Level (VDC)	DC Level Shift Interpretation: Effect Observed?	Comment
			Wednesday 25 September 2019					
810	719	off	Detector ops check - static - mic keyed near detector		0.04	**1.9**	N/A	Detector working
817	721	43 kV	Charged Spindle - static		0.2		N/A	delayed corona development
825	722	**43 kV**	**Charged Spindle** - mission low to 78 krpm	Manual	0.2	0	**Not Observed**	
838	723	**43 kV**	**Charged Spindle** - mission low to 78 krpm	Manual	0.2	0	**Not Observed**	
852	724	**43 kV**	**Charged Spindle** - mission low to 78 krpm	Manual	0.2	0	**Not Observed**	
855	725	**43 kV**	**Charged Spindle** - mission low to 95 krpm	Manual	0.2	0	**Not Observed**	
906	726	**43 kV**	**Charged Spindle** - mission low to 95 krpm	Manual	0.2	0	**Not Observed**	Not recorded
919	727	**43 kV**	**Charged Spindle** - mission high to 98 krpm	Manual	0.2	0	**Not Observed**	
926	728	**43 kV**	**Charged Spindle** - mission low to 98 krpm	Manual	0.2	0	**Not Observed**	
941	729	**43 kV**	**Charged Spindle** - 10 saw-tooth cycles to 98 krpm	Auto	0.2	0	**Not Observed**	
950	730	**43 kV**	**Charged Spindle** - 6 min dwell at 100 krpm	Auto	0.2	0	**Not Observed**	
	Installed New Grounding Brush, old brush had negligible wear - could not tell from new							
1030	731	**43 kV**	**Charged Spindle** - 8 saw-tooth cycles to 100 krpm	Auto	0.2	0	**Not Observed**	Grnd Brush #2 installed
1036	732	**43 kV**	**Charged Spindle** - dwell time at 100 krpm	Auto	0.2	0	**Not Observed**	
1042	***Switched to RSF facility air compressor 125 psig 3" air supply line (from regulated Shop Air 3/4" supply line)***							
1045	733	**43 kV**	**Charged Spindle** - stair step 80 k to 100 k rpm with dwell	Auto	0.2	0	**Not Observed**	collecting valve offsets for spd control
1050	734	**43 kV**	**Charged Spindle** - rapid saw-tooth cycles to 100 krpm	Auto	0.2	0	**Not Observed**	
1053	735	**43 kV**	**Charged Spindle** - one saw-tooth cycles to 100 krpm	Auto	0.2	0	**Not Observed**	
	736	**43 kV**	**Charged Spindle** - one cycle to 40 krpm	Auto	0.2	0	**Not Observed**	
1056	737	**43 kV**	**Charged Spindle** - 3 rapid saw-tooth cycles to 100 krpm	Auto	0.2	0	**Not Observed**	
1058	738	**43 kV**	**Charged Spindle** - 6 rapid saw-tooth cycles to 100 krpm	Auto	0.2	0	**Not Observed**	
1042	***Increased sensitivity of EM Flux Detector by removing 50 ohm resistor at Detector antenna coil input***							
1350	739	**43 kV**	**Charged Spindle** - 10 rapid saw-tooth cycles to 100 krpm followed by dwell time at 100 krpm	Auto	0.2	0	**Not Observed**	
1405	741	**43 kV**	**Charged Spindle** - mission low to 100 krpm	Manual	0.2	0	**Not Observed**	
1411	742	**43 kV**	**Charged Spindle** - mission high to 100 krpm	Manual	0.2	0	**Not Observed**	
1423	743	**43 kV**	Intermittent **Charged Spindle** - dwell time at 100 krpm	Auto	0.2	0	**Not Observed**	
1437	744	**43 kV**	Intermittent **Charged Spindle** - 7 rapid saw-tooth cycles to 100 krpm	Auto	0.2	0	**Not Observed**	
1538	745	off	Spindle Dynamics - stair step to 100 krpm	Manual	N/A	N/A	N/A	proximity probe on

DISCUSSION

109. It was critical for evaluation of the HEEMFG effect from the EM Flux Detector's output that electrical contact was maintained between the graphite grounding brush and the rotating spindle at negative ground potential. Any intermittent contact (or skipping) of the graphite brush with the spindle would interrupt the high voltage spindle charging circuit and cause the charge on the spindle to fluctuate. A fluctuation in spindle charge generates a changing EM flux that would be sensed by the EM Flux Detector increasing its output level generating a false indication of the HEEMFG effect. The connection was checked out mechanically with the spindle installed in the air motor by measuring, with a dial indicator, the total indicated runout (axial) of the spindle's grounding brush contact surface; it was very good at .0003 inches. Several times throughout the testing, continuity checks were made between the grounded spin chamber lid and the graphite brush and the spindle, the brush was inspected, and the contact surface was cleaned with alcohol. No degradation of the brush was observed. There was no practical method for indication of intermittent brush contact during the test; however, because the EM Flux Detector's noise levels with a charged spindle were very stable without intermittent shifts, it is reasonable to conclude that the electrical grounding path was maintained and the graphite brush was not skipping.

CONCLUSION

110. The spin test to evaluate the HEEMFG effect was successful in spinning a charged spindle with an estimated 2.9 x 10E-08 coulomb surface charge at one end of the spindle, at speeds up to 100 krpm/s with acceleration rates in the +/- 30 krpm/s range in a vacuum level of 0.4 torr. The experimental equipment for generating and maintaining the surface charge on the spindle and the instrumentation for detecting the HEEMFG effect performed well.

111. The HEEMFG effect was not observed or disproved in the tested configuration.

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The high energy electromagnetic field generator

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Abstract: The original concept described is named the high energy electromagnetic field generator. This concept's governing physics entail the coupling of gyration (high frequency spin), vibration (high frequency abrupt pulsations/harmonic oscillations) and possible curvilinear translation, of electrically charged systems. If we couple the system's high frequency of rotation (30,000 to 100,000 RPM, and higher) with high vibration (abrupt pulsations/harmonic oscillations) frequencies in the range of 10^9 to 10^{18} Hertz (and above) we can obtain electromagnetic field intensity values in the range 10^{24} to 10^{28} Watts/m^2 (and beyond). These extremely high electromagnetic field intensity values emphasise the novelty of this concept, especially suited for the design of energy generation machinery with power output levels much higher than those currently achievable. The utilisation of such high power sources for space power and propulsion generation, as it pertains to reduction in a spacecraft's inertial mass as a direct result of local vacuum polarisation, is an important application of the described theoretical concept. In this manner, extreme spacecraft speeds can be achieved.

Keywords: faster than light travel; superluminal propulsion; quantum vacuum plasma; QVP; vacuum energy fluctuations; vacuum polarisation; spacetime manipulation; quantum vacuum engineering; quantum field theory; far from equilibrium thermodynamics; spatio-temporal excursion.

Reference to this paper should be made as follows: Pais, S.C. (2015) 'The high energy electromagnetic field generator', *Int. J. Space Science and Engineering*, Vol. 3, No. 4, pp.312–317.

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1 Introduction

The original concept described herein, is named the high energy electromagnetic field generator (HEEMFG). When put in practice, this system can provide the design of energy generation machinery with power output levels much higher than those currently achievable. The utilisation of such high power sources for space power and propulsion generation, as it pertains to reduction in the spacecraft's inertial mass as a direct result of local vacuum polarisation, is an important application of the described theoretical concept.

This concept's governing physics entail the coupling of gyration (high frequency spin), vibration (high frequency abrupt pulsations/harmonic oscillations) and possible curvilinear translation (thus three modes of motion) of electrically charged systems.

There are four known fundamental forces which control matter and therefore control energy, namely the strong and weak nuclear forces, the electromagnetic (EM) force and the gravitational force. In this hierarchy of forces, the EM force is perfectly positioned to be able to manipulate the other three. A stationary electric charge gives rise to an electric (electrostatic) field, while a moving charge generates both an electric and a magnetic field (hence, the EM field); additionally an accelerating charge induces EM radiation in the form of transverse waves, namely light. Mathematically as well as physically, EM field intensity can be represented as the product of electric field strength and magnetic field strength. EM fields act as carriers for both energy and momentum, thus interacting with physical entities at the most fundamental level.

Artificially generated, high energy, EM fields interact strongly with the vacuum energy state (an aggregate/collective state comprised of the superposition of all quantum fields' fluctuations permeating the entire fabric of spacetime), thereby giving rise to emergent physical phenomena (in other words revolutionary/new physics), such as force and matter fields unification. According to quantum field theory, this strong interaction between the fields is based on the mechanism of transfer of vibrational energy between the fields, further inducing local fluctuations in adjacent quantum fields which permeate spacetime (these fields may or may not be EM in nature). Matter, energy, and spacetime are all emergent constructs which arise out of the fundamental framework that is the vacuum energy state.

Everything that surrounds us, ourselves included, can be described as macroscopic collections of fluctuations, vibrations, oscillations in quantum mechanical fields. Matter is confined energy, 'frozen' in a quantum of time. Therefore, under certain conditions (such as the coupling of hyper-frequency axial spin with hyper-frequency vibrations of electrically charged systems) the rules and special effects of quantum field behaviour also apply to macroscopic physical entities (O'Connell et al., 2010).

Moreover, coupling of hyper-frequency gyrational (axial rotation) and hyper-frequency vibrational electrodynamics (as used in the concept herein disclosed) is conducive to a possible physical breakthrough (force field unification is feasible with the concept at hand) in the utilisation of the macroscopic quantum fluctuations vacuum plasma field (quantum vacuum plasma – QVP, in short) as an energy source (or sink), an induced physical phenomenon, for which the technology readiness level has been considerably advanced by a team of research engineers from NASA JSC (Brady et al., 2014). This research involves the use of high radio frequency/microwave driven resonant cavity Q-thruster technology within the context of QVP physics.

The QVP is the electric glue of our plasma universe. The Casimir effect, the Lamb shift, and spontaneous emission, are specific confirmations of the existence of QVP (Milonni, 1994).

It is important to note that in region(s) where the EM fields are strongest, the more potent are the interactions with the QVP, therefore, the higher the induced energy density of the QVP particles which spring into existence(the Dirac Sea of electrons and positrons). These QVP 'particles' may augment the obtained energy levels of the HEEMFG system (even though they are short-lived, these 'virtual' particles have a real effect).

To be more precise, the EM fields created by the HEEMFG system, interact with the vacuum energy state, which is an aggregate state composed of the superposition of all quantum fields' fluctuations filling the entire fabric of spacetime. Contributions to this vacuum state energy density are made by the quantum vacuum-zero point fluctuations, the quantum chromo-dynamics gluon and quark condensates and the newly discovered Higgs field (exhibiting massive 126 GeV particles), among other yet undiscovered fields (super-symmetry). In other words, major contributions to the vacuum energy state are made by collectives of quantum fluctuations in fermionic fields (fields of matter), quantum fluctuations in bosonic fields (fields of force) and quantum fluctuations in scalar fields (Higgs field).

2 Concept novelty

The physical equation which describes the maximum intensity achieved by the HEEMFG system is described by the magnitude of the Poynting vector, which in non-relativistic form (accounting for all three modes of motion) can be written as:

$$S_{max} = f_G \left(\sigma^2 / \varepsilon_0\right)\left[R_r\omega + R_v v + v_R\right] \quad (1)$$

where f_G is the HEEMFG system geometric shape factor (equal to 1 for a disc configuration), σ is the surface charge density (total electric charge divided by surface area of the HEEMFG system), ε_0 is the electrical permittivity of free space, R_r is the radius of rotation (disc radius), ω is the angular frequency of rotation in rad/s, R_v is the vibration (harmonic oscillation) amplitude, v is the angular frequency of vibration in Hertz, and the term v_R is the curvilinear translation speed (acquired via a propulsive unit of either chemical, nuclear or magneto-plasma-dynamic (VASIMR) type attached to the HEEMFG system – the integrated unit being the spacecraft).

Therefore, if we consider only rotation, given a disc configuration, with σ = 50,000 Coulombs/m^2, a disc (spinning/axially rotating) radius of 2 m and an angular speed of 30,000 RPM, we can generate an EM field intensity (S_{max} = rate of energy flow per unit area, or energy flux) value on the order of 10^{24} Watts/m^2 (this value does not account for any QVP interactions).

Furthermore, if we couple the high frequency of rotation with high vibration (harmonic oscillation) frequencies in the range of 10^9 to 10^{18} Hertz (and above) we can obtain S_{max} intensity values in the range 10^{24} to 10^{28} Watts/m^2 (and beyond). These extremely high EM field intensity values emphasise the novelty of this concept, especially suited for the design of energy generation machinery with power output levels much higher than those currently achievable.

For the case of an accelerating angular frequency of vibration ($a_{max} = R_v v^2$), neglecting rotation and curvilinear translation, equation (1) becomes (note intrinsic significance of acceleration):

$$S_{max} = f_G\,(\sigma^2 / \varepsilon_0)\left[(R_v v^2)\,t_{op}\right] \tag{2}$$

where t_{op} is the operational time for which the charged electrical system is accelerating.

Close inspection of equation (2) results in an important realisation, namely: strong local interaction with the high energetics of the quantum vacuum fields' fluctuations superposition (macroscopic vacuum energy state) is possible in a laboratory environment, by application of high frequency gyration and/or high frequency vibration of minimally charged objects (order of unity), in an acceleration mode. In this manner, a high degree of vacuum energy polarisation can be achieved.

Local polarisation of the vacuum in the close proximity of a spacecraft equipped with an HEEMFG system would have the effect of cohering the highly energetic and random quantum vacuum fields' fluctuations, which virtually block the path of an accelerating spacecraft, in such a manner that the resulting negative pressure of the polarised vacuum allows less laboured motion through it (Froning, 2009).

Spontaneous electron-positron pair production out of the vacuum (Schwinger, 1951; Kim, 2015) is a strong indicator of vacuum polarisation being achieved. Schwinger gives a value of the electric field (E) on the order of 10^{18} V/m for this phenomenon to take place. The mass production rate $(dm / dt)_{pp}$ of particle/anti-particle pairs can be expressed in terms of S_{max} (energy flux), namely:

$$2_\gamma\,(dm / dt)_{pp}\,c^2 = S_{max} A_S \tag{3}$$

where A_S is the surface area from which the energy flux emanates, c is the speed of light in free space, and (γ) is the relativistic stretch factor $[1 - (v^2 / c^2)]^{-1/2}$. Note that the pair production rate increases with increasing energy flux from the spacecraft's generated EM field. Therefore, the level, to which the vacuum is polarised, thus allowing less laboured motion through it, strictly depends on the artificially generated EM energy flux.

If we consider the boundary condition in the close proximity of the spacecraft where the energy density of the artificially generated EM field equals the local energy density of the polarised vacuum (caused in part by the local zero-point vacuum fluctuations on the order of 10^{-15} Joules/cm^3 and in part by the artificial EM field interacting with the local vacuum energy state) we can write the approximate equivalence:

$$S_{max}\,(t_{op} / R_S) = \left[(h^* v_v^4)/8\pi^2 c^3\right] \tag{4}$$

where R_S is the electromagnetic (EM) field radius at EM wave propagating time t_{op}, such that $R_S / t_{op} = c$ (where c is the light speed in free space), (h^*) is Planck's constant divided by (2π) and (v_v) is the frequency of quantum fluctuations in the vacuum (modelled as harmonic oscillators).

Furthermore, given that the left side of equation (4) is on the order of ($\varepsilon_0 E^2$) where E is the artificially generated electric field (strength), considering the Schwinger value of (E) for the onset of spontaneous pair production, we obtain a (v_v) value on the order of 10^{22} Hertz, which matches our expectations, since the Dirac virtual pair production, results in total annihilation, yielding gamma rays, which occupy the EM frequency spectrum of 10^{19} Hertz and above.

A recent paper (Pais, 2015) considers the possibility of superluminal spacecraft propulsion in a special relativity framework. It is observed that under certain physical conditions, the singularity expressed by the relativistic stretch factor 'gamma' as the spacecraft's speed (v) approaches the speed of light (c), is no longer present in the physical picture. This involves the instantaneous removal of energy-mass from the system (spacecraft) when the spacecraft's speed reaches (v = c / 2). The author discusses the possibility of using exotic matter (negative mass/negative energy density) to bring about this effect. This may not have to be the only alternative. The artificial generation of gravity waves in the locality of the spacecraft, can result in energy-mass removal (gravity waves are propagating fluctuations in gravitational fields, whose amplitude and frequency are a function of the motion of the masses involved).

Moreover, it is feasible to remove energy-mass from the system by enabling vacuum polarisation, as discussed by Puthoff (Puthoff, 2002; Haisch et al., 1994); in that diminution of inertial (and thus gravitational) mass can be achieved via manipulation of quantum field fluctuations in the vacuum. In other words, it is possible to reduce a spacecraft's inertia, that is, its resistance to motion/acceleration by polarising the vacuum in the close proximity of the moving spacecraft. As a result, extreme speeds can be achieved.

Think of the vacuum energy state as a chaotic system comprised of random, highly energetic fluctuations in the collective quantum fields which define it. Considering Prigogine's (1977) work on far from equilibrium thermodynamics, a chaotic system can self-organise if subjected to three conditions, namely: the system must be nonlinear, it must experience an abrupt excursion far from thermodynamic equilibrium, and it must be subjected to an energy flux (order from chaos).

An artificially generated high energy EM field can fulfil all three conditions simultaneously, when strongly interacting (especially in an accelerated vibration/rotation mode) with the local vacuum energy state. Recall that these interactions are induced by the coupling of hyper-frequency axial rotation (spin) and hyper-frequency vibration (harmonic oscillations/abrupt pulsations) of electrically charged systems (HEEMFG), placed on the outside of the spacecraft in strategic locations. In this manner, local vacuum polarisation, namely the coherence of vacuum fluctuations within the immediate proximity of the spacecraft's surface (outside vacuum boundary) is achieved, allowing for 'smooth sailing' through the negative pressure (repulsive gravity) of the void.

As an aside, force and matter fields unification (Gross, 2007) is feasible with the concept at hand, due to the extremely strong interactions (EM in nature) between ordinary matter and the QVP/vacuum energy state (interactions which exhibit extremely high energies on Planck length scales in the immediate proximity of the disc/spacecraft surface).

3 Conclusions

This original concept, which may represent a breakthrough technology, does reveal a novel approach to the design of energy generation machinery with power output levels much higher than those currently achievable by conventional means.

The utilisation of such high power sources for space power and propulsion generation, as it pertains to reduction in the spacecraft's inertial mass as a direct result of local vacuum polarisation, is an important application of the described theoretical concept. In this manner, extreme spacecraft speeds can be achieved.

To be more exact, the concept at hand can be utilised in the design of a device to manipulate/modify the local spacetime lattice (topology) energy density, which can be achieved via local vacuum energy polarisation. Moreover, due to the nature of the 'emergent physics' involved, it is possible to experience spatio-temporal displacement (excursion) effects.

Disclaimer

The views espoused and conclusions reached in this technical paper are the author's own, and do not necessarily reflect the views or beliefs of the US Government and the Department of the Navy.

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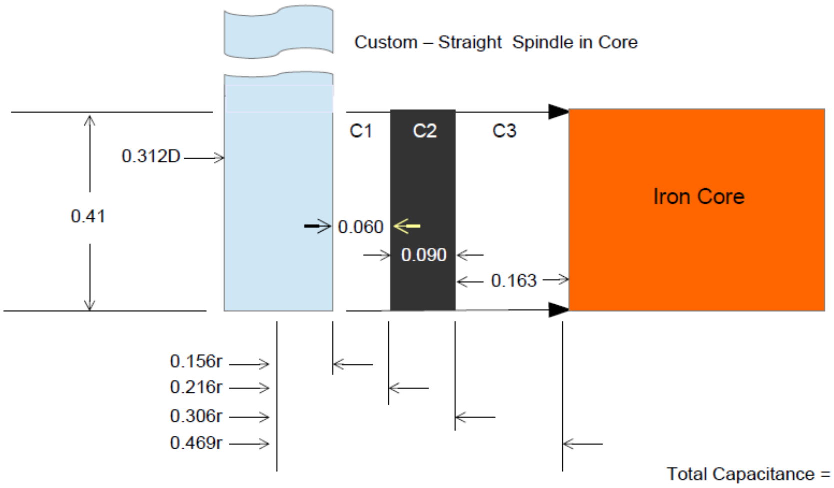
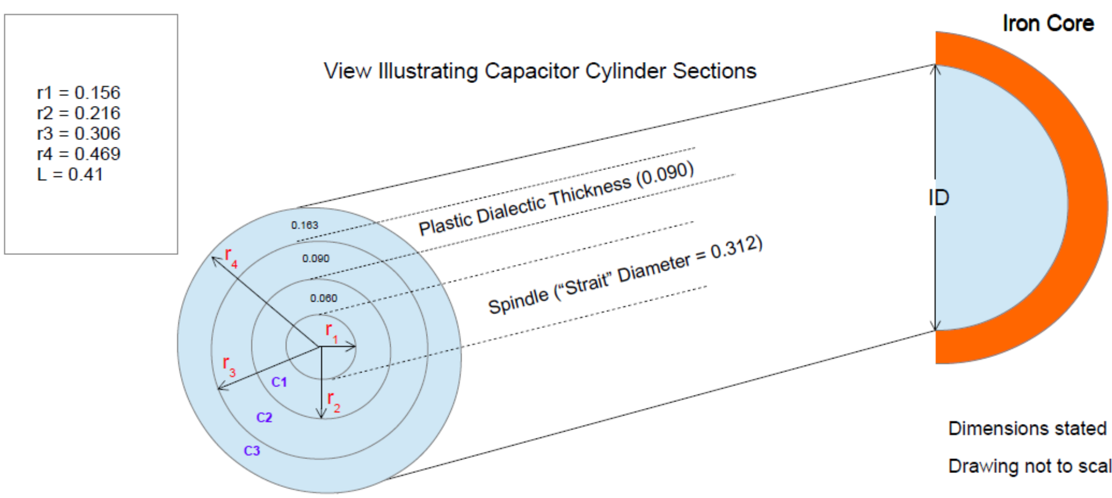
Appendix B (Spindle Charge Calculation)



Total Capacitance = 3 section cylinder 1/Ct = 1/C1 + 1/C2+ 1/C3



Dimensions stated in inches

Drawing not to scale

(b)(6) [redacted] 09/28/2019

Custom – Straight Spindle											
π	Ɛo (F/ inch)	k	L	Numerator			r1	r2	r3	r4	
3.14159265358979	2.24896370444877E-013						0.156	0.216	0.306	0.469	
	C1	1	0.41	5.793569E-013			r2/r1	r3/r2	r4/r3		
	C2	3.7	0.41	2.143620E-012		ratio	1.38462	1.4167	1.5327		
	C3	1	0.41	5.793569E-013		ln	0.32542	0.3483	0.427	Denominator	
							C1	C2	C3		
C1 =	1.78032269166874E-012	F									
C2 =	6.15440502751948E-012	F									
C3 =	1.35675155697419E-012	F									

Ctotal = 6.84352251621007E-013 Farad or 0.68pF

Charge @ 43KVDC = 2.94271468197033E-008 Coulombs

1 electron, 1e, has a charge of 1.60217646E-019	
Total electrons	1.83669823858E+011

183,669,823,858 e

[redacted]

Cylinder Capacitance Equation - For each capacitor cylinder section; C_1, C_2 and C_3:

$$C_{SectionX} = \frac{2 * \pi * \varepsilon_0 * k_{SectionX} * L_{SectionX}}{\ln\left(r_{SectionXouter} / r_{SectionXinner} \right)}$$

For cylinders separated by different dielectric material, each section capacitance combines by the series capacitance equation:

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$\varepsilon_0 = 8.85 * 10^{-12}$ F/m; 1m = 39.3700787402 inches; $\varepsilon_0 = 2.25 * 10^{-13}$ F/inch (see note below).

k = 1.00000 for Free Space (vacuum).
k = 1.00059 for Air (dry).
k = 3.70 Acetals Copolymer.

L = Length of cylinder within core = 0.41inches.

[redacted]

Note: these value utilized in spreadsheet.

ε_0 = 8.8541878128×10−12 F/m−1 (Farads per meter)

ε_0 = 2.24896370444877x10-13 F/inch (Farads per inch)

Appendix C (Test Specific Hardware Drawings)

GROUNDING BRUSH HOLDER - rev. 1

Revision 1 - 27Aug2019

DATE: 15 April 2019

(b) (6) [redacted]

PROJECT: HEEMFG Spin Test

MATERIAL: Aluminum 6061T6

APPLICATION: Mounts two Helwig Carbon model BPK-IM2 graphite brushes onto 2" air motor to electrically ground rotating spindle - one vertical for axial contact and one horizontal for radial contact

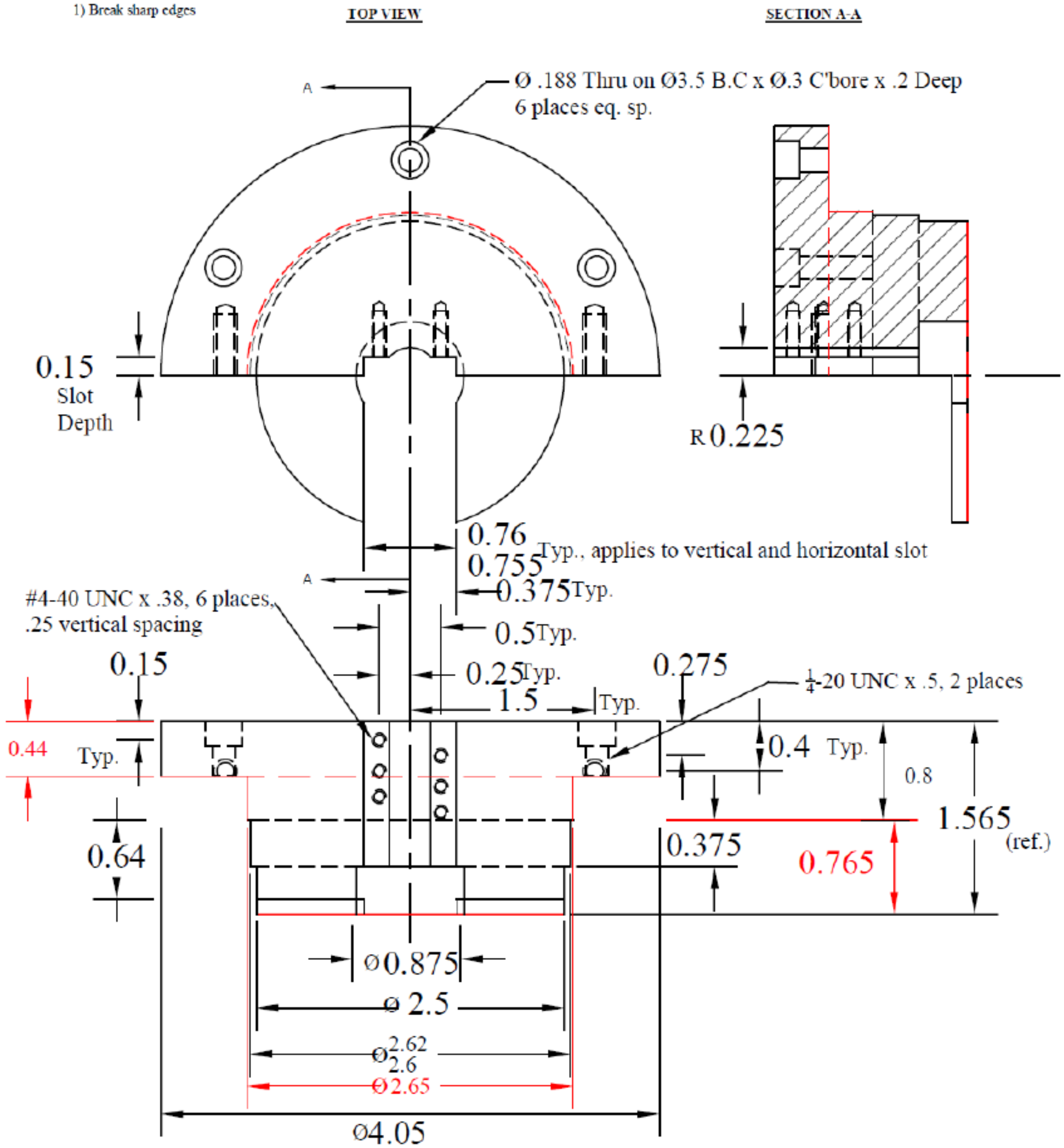
DIMENSIONS: inches

TOLERANCES: +/- .005 unless otherwise specified

SURFACE FINISH: 63 micro-inches all over unless otherwise specified

NOTES:

1) Break sharp edges



FOR OFFICIAL USE ONLY

22 August 2019
REVISION 1:
Change .56" to .180

DATE: 10 April 2019

(b)(6) [redacted]

$\frac{5}{16}$" SPINDLE WITH GROUNDING BRUSH CONTACT

PROJECT: HEEMFG Spin Test

MATERIAL: 4340 per AMS6415 hardened to 32 - 36 Rc

APPLICATION: 100,000 rpm spin test with spindle electrically grounded

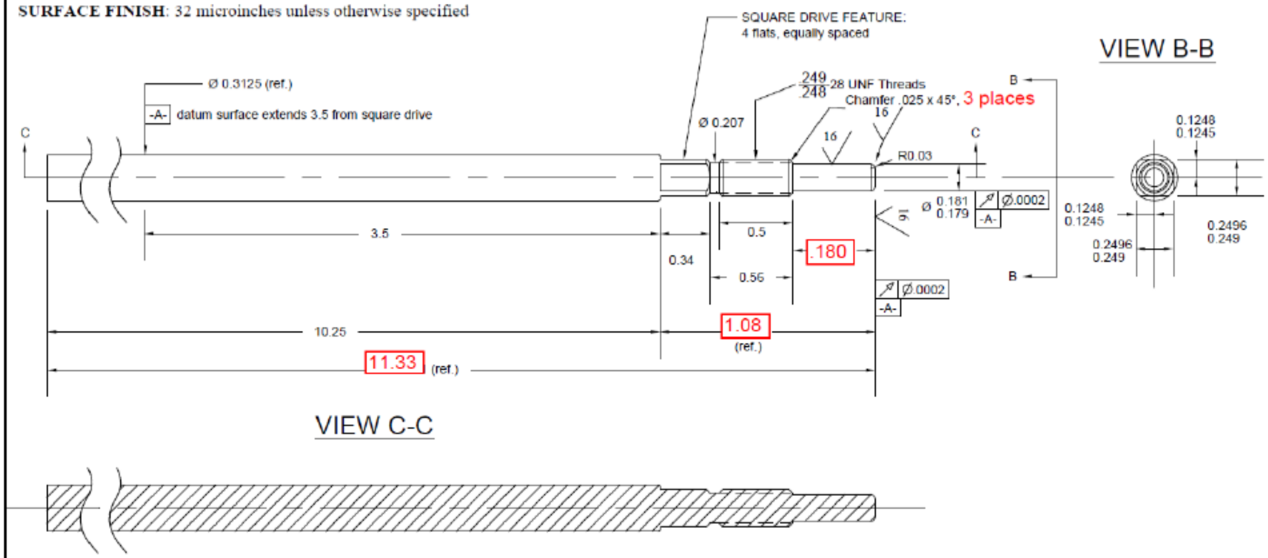
MAKE FROM: Spindle Blank Ø.3125" x 23" length, part no. 2529-B, available from Barbour Stockwell, Inc., 45 Sixth Road, Woburn, MA 01801, Ph:781-933-5200 for $50.00 each.

DIMENSIONS: inches

TOLERANCES: +/- .01 unless otherwise specified

SURFACE FINISH: 32 microinches unless otherwise specified

NOTES:
1) Break sharp edges .003 - .01
2) Preserve surface finish / straightness of Spindle Blank
3) Measure and record overall spindle straightness



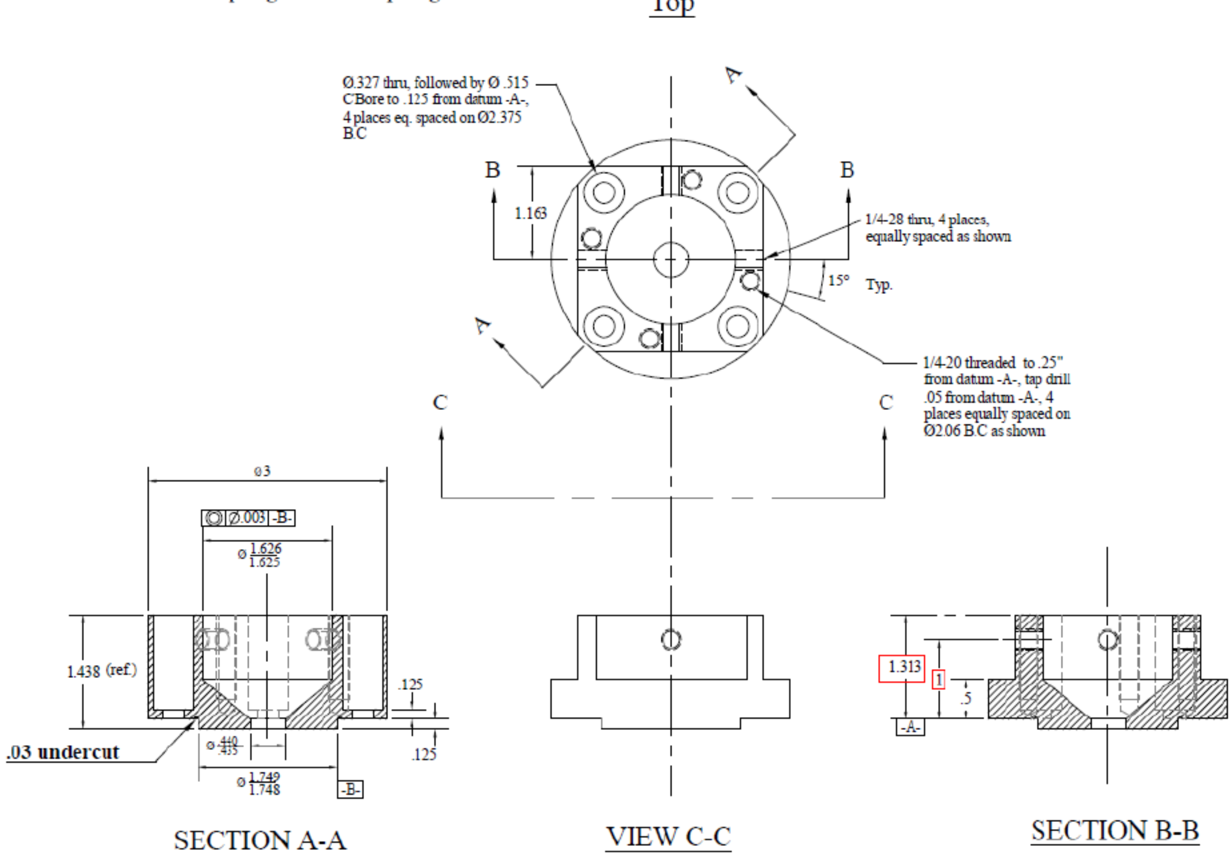
Proximity Probe Mount

Date: 12 May 2019
[redacted]
NAVAIR 4.4.6.4
[redacted]

Project: HEEMFG Spin Test (FY19)

Material: Aluminum 6061 T6
Dimensions: inches
Surface: 63 micro-in all over unless otherwise specified
Tolerances: +/- .005 unless otherwise specified

NOTES
1. Break all sharp edges - No Sharp Edges.



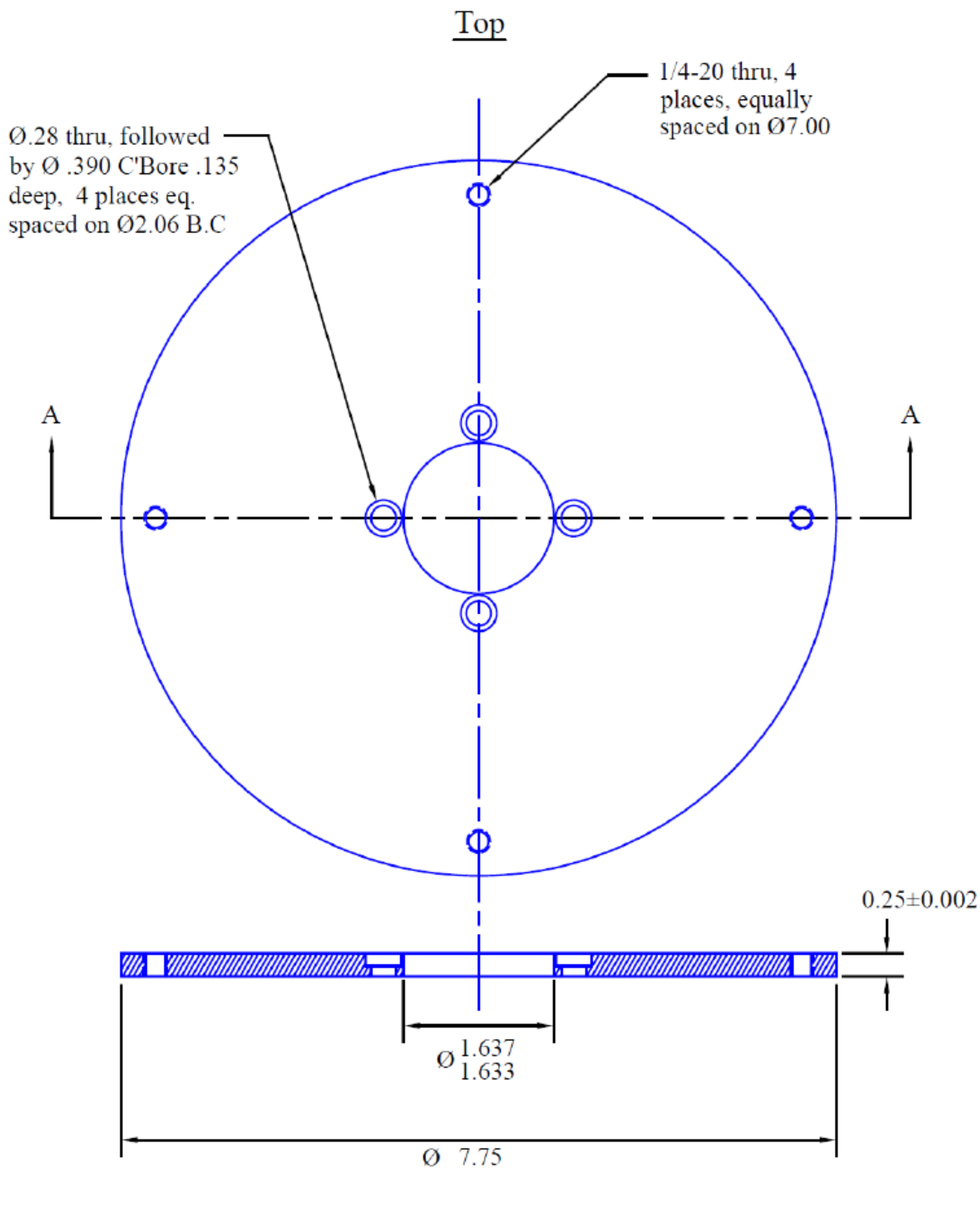
Adapter Plate

Project: HEEMFG Spin Test (FY19)

Date: 12 May 2019
POC: [redacted]
NAVAIR 4.4.6.4
PH: [redacted]

Material: Precision Ground 4140 Steel Plate (McMaster-Carr item #8892K97)
Dimensions: inches
Surface: 63 micro-in all over unless otherwise specified
Tolerances: +/- .005 unless otherwise specified

NOTES
1. Break all sharp edges - No Sharp Edges.



SECTION A-A

Iron Core

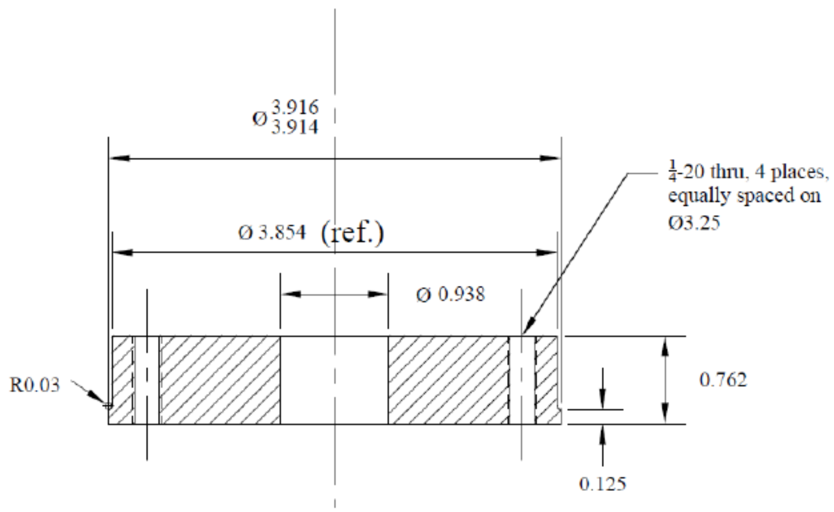
Date: 12 May 2019
POC: [redacted]
NAVAIR 4.4.6.4
PH: [redacted]

Project: HEEMFG Spin Test (FY19)

Material: Cast Iron (McMaster-Carr item #8909K84 or equiv.)
Dimensions: inches
Surface: 63 micro-in all over unless otherwise specified
Tolerances: +/- .005 unless otherwise specified

NOTES
1. Break all sharp edges - No Sharp Edges.

Cross Section View



Dielectric Insulator

Project: HEEMFG Spin Test (FY19)

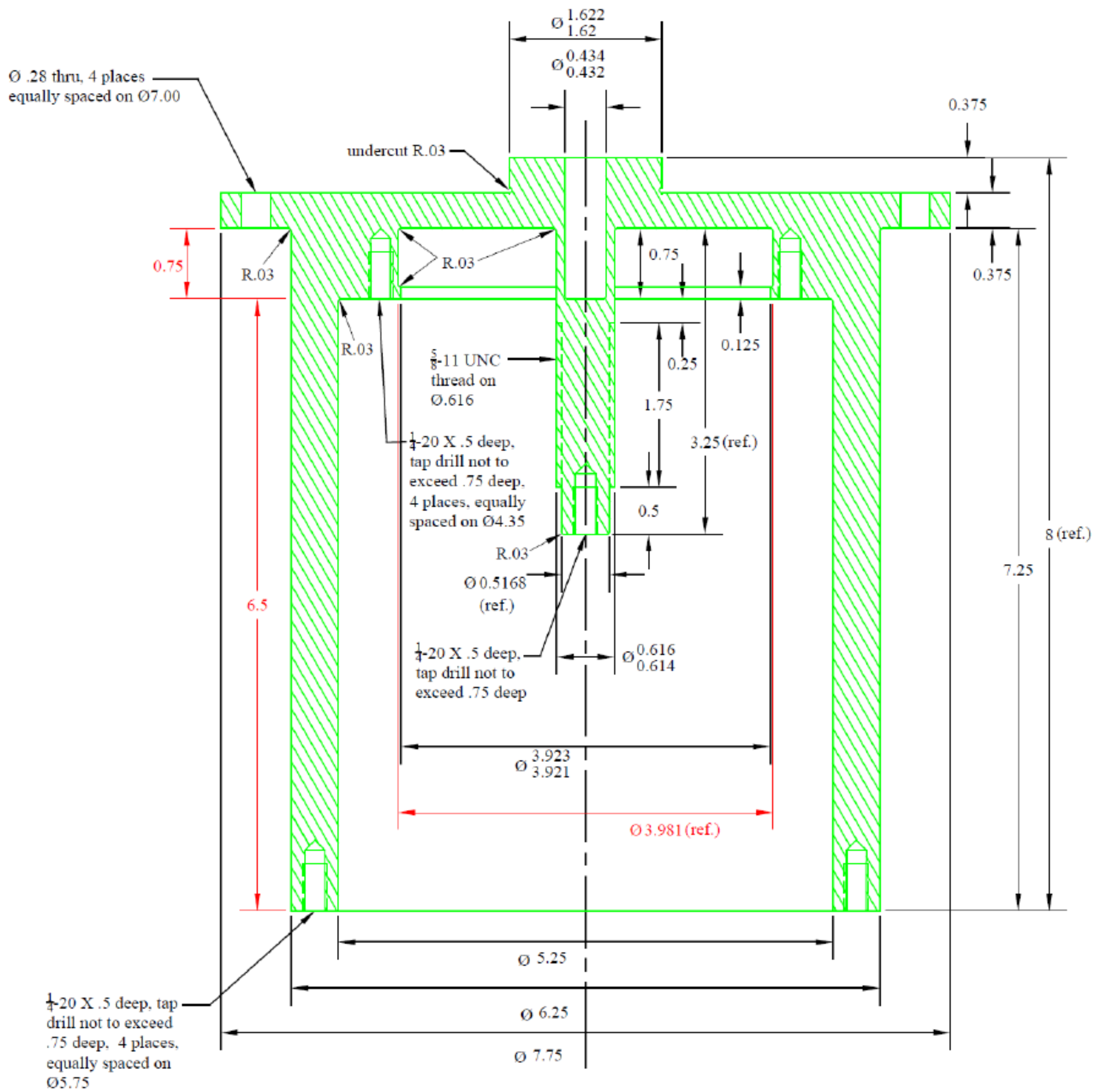
DATE: 12 May 201
POC: (b) (6) [redacted]
NAVAIR 4.4.6.4
Ph: (b) (6) [redacted]

MATERIAL: Acetal Copolymer (PolyOxyMethylene - Copolymer POM-C) <u>with no centerline porosity.</u> Available from Nationwide Plastics Inc. Do not use Delrin (Aectal Homopolymer)

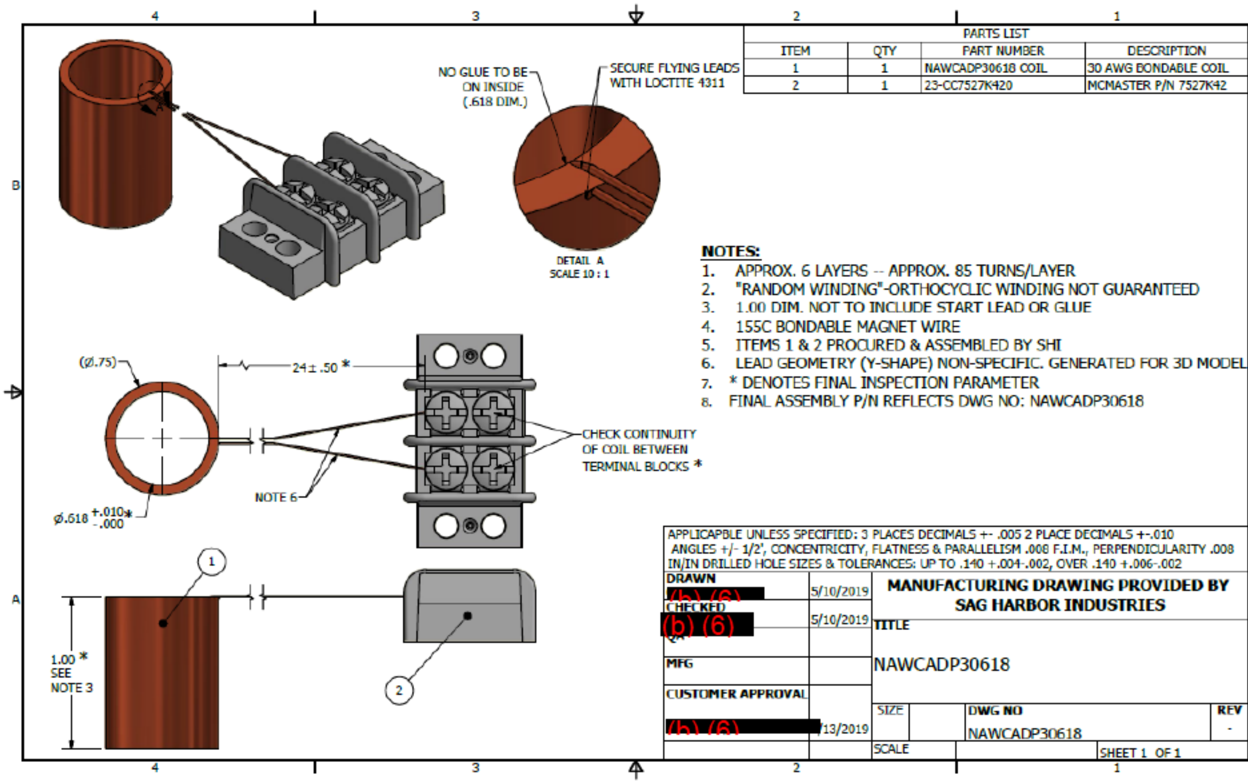
DIMENSIONS: inches
SURFACE FINISH: 63 micro-in all over
TOLERANCES: +/- .005 unless otherwise specified

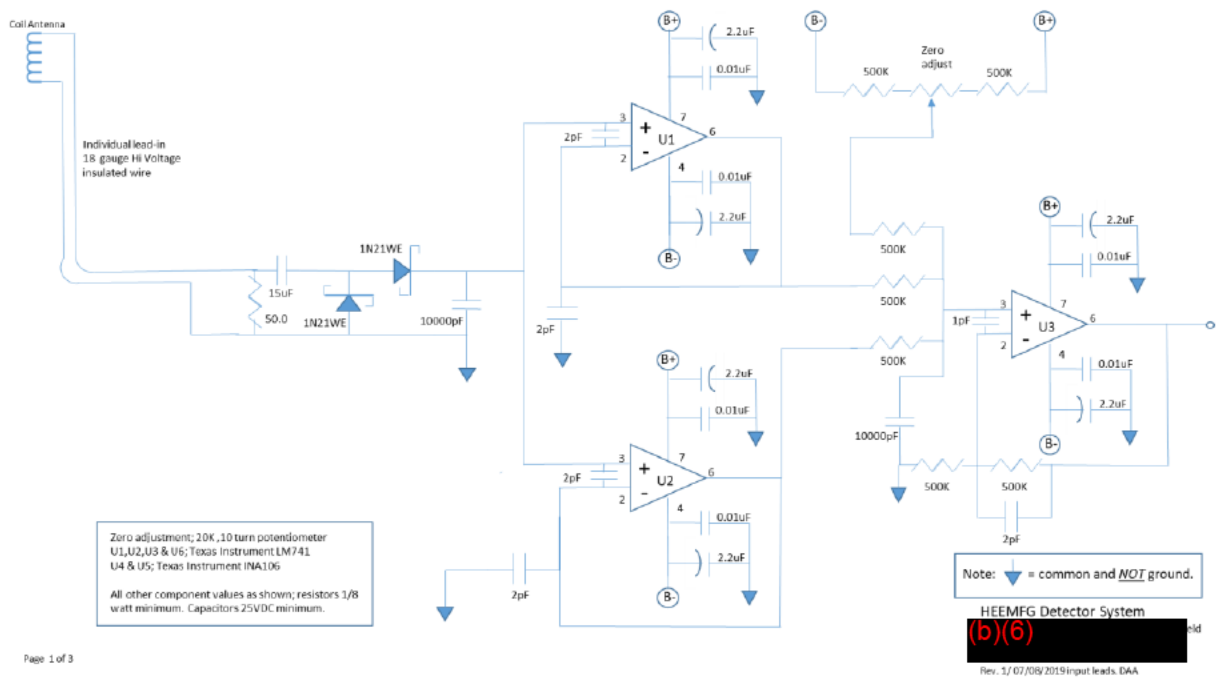
NOTE: Break All Sharp Edges - No Sharp Edges

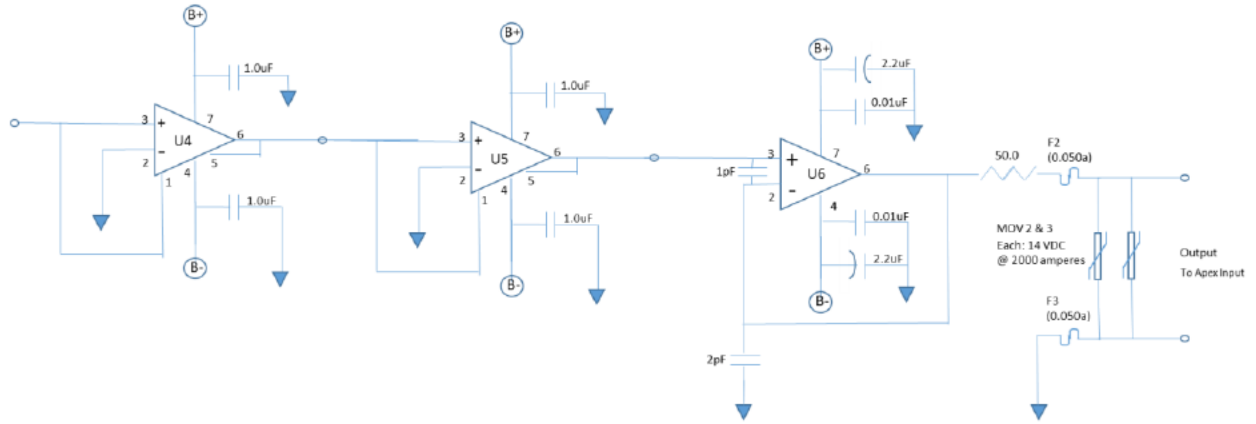
Top



Appendix D (Test Specific Instrumentation Diagrams)



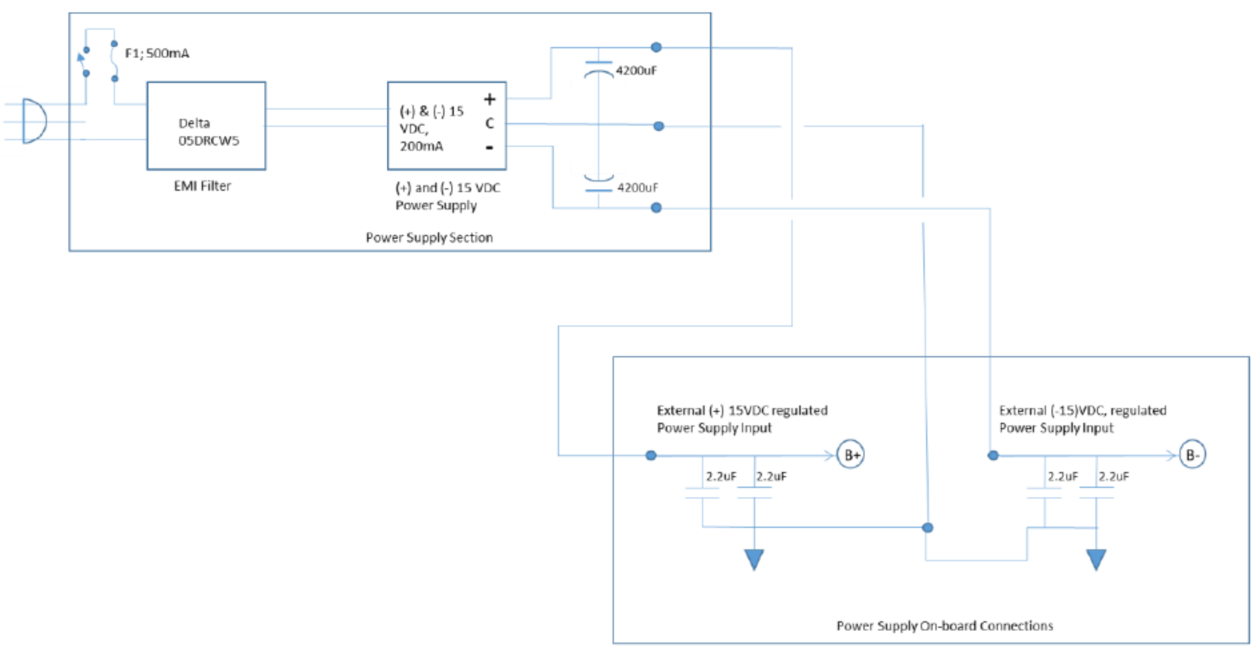




Note: Differential input (Full Floating) @ Apex mandatory.

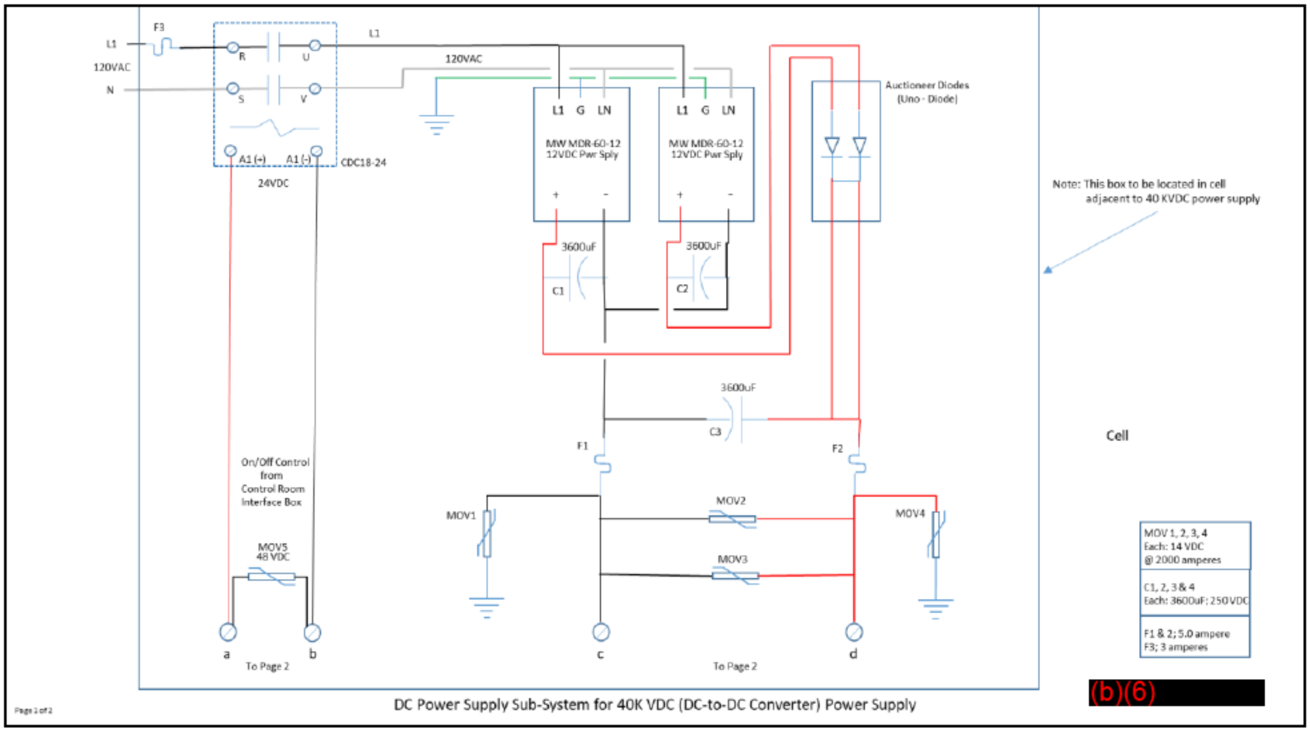
HEEMFG Detector System
Electro-Magnetic Field, Including Pure B- Field
(b)(6) [redacted]

Page 2 of 3

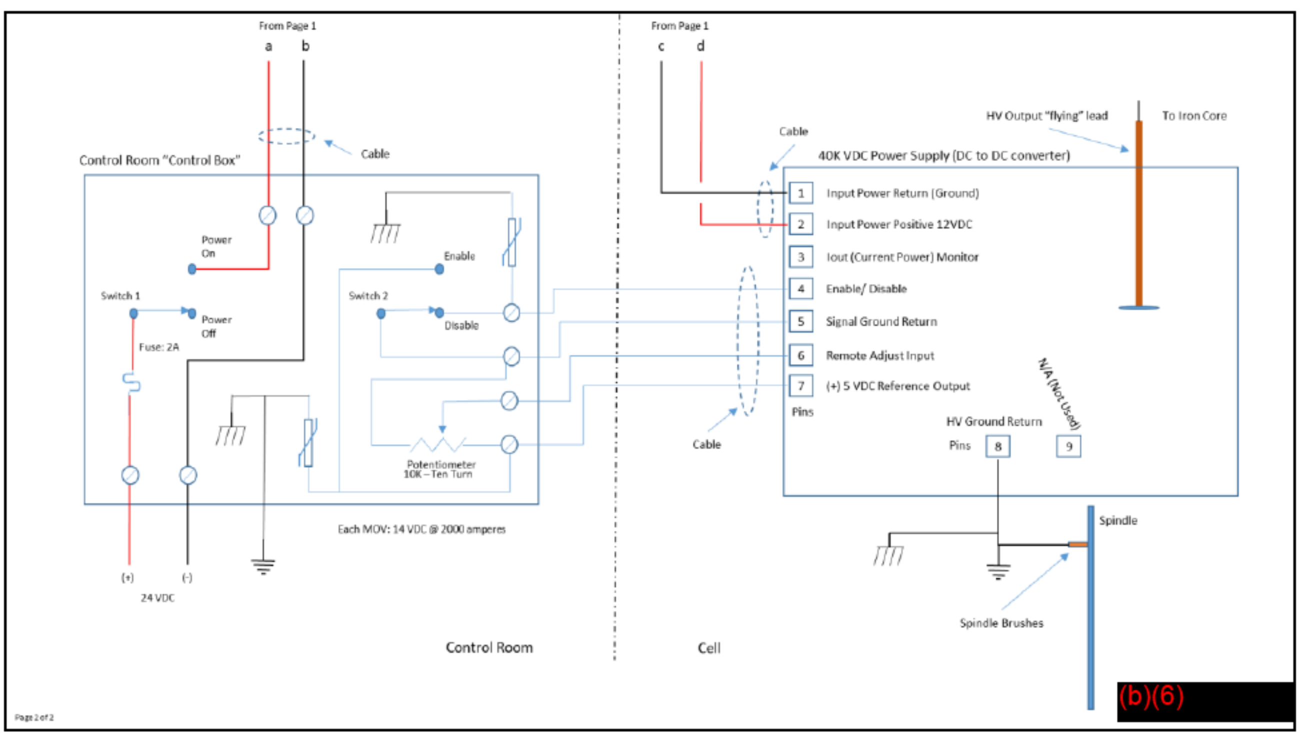


HEEMFG Detector System
Electro-Magnetic Field, Including Pure B- Field
(b)(6) [redacted]

Page 3 of 3



F3
L1
120VAC
N
R
U
S
V
A1 (+)
A1 (-)
CDC18-24
24VDC
L1
120VAC
L1 G LN
MW MDR-60-12
12VDC Pwr Sply
L1 G LN
MW MDR-60-12
12VDC Pwr Sply
Auctioneer Diodes
(Uno - Diode)
Note: This box to be located in cell adjacent to 40 KVDC power supply
3600uF
C1
3600uF
C2
3600uF
C3
F1
F2
Cell
On/Off Control from Control Room Interface Box
MOV5
48 VDC
MOV1
MOV2
MOV3
MOV4
MOV 1, 2, 3, 4
Each: 14 VDC
@ 2000 amperes
C1, 2, 3 & 4
Each: 3600uF: 250VDC
F1 & 2; 5.0 ampere
F3; 3 amperes
a
b
c
d
To Page 2
To Page 2
(b)(6) [redacted]
Page 1 of 2
DC Power Supply Sub-System for 40K VDC (DC-to-DC Converter) Power Supply



From Page 1
a b
From Page 1
c d
Cable
Control Room "Control Box"
Power On
Enable
Switch 1
Switch 2
Power Off
Disable
Fuse: 2A
Potentiometer
10K – Ten Turn
(+)
(-)
24 VDC
Each MOV: 14 VDC @ 2000 amperes
Cable
HV Output "flying" lead
To Iron Core
40K VDC Power Supply (DC to DC converter)
1 Input Power Return (Ground)
2 Input Power Positive 12VDC
3 Iout (Current Power) Monitor
4 Enable/ Disable
5 Signal Ground Return
6 Remote Adjust Input
7 (+) 5 VDC Reference Output
Pins
N/A (Not Used)
HV Ground Return
Pins 8 9
Cable
Spindle
Spindle Brushes
Control Room
Cell
(b)(6) [redacted]
Page 2 of 2

Appendix E (Daily Checklist)

The following daily checklist has been prepared by the test technician.

INTRODUCTION

The Rotor Spin Facility (RSF), located in the Propulsion Systems Facility (BLDG 2360), performs evaluations of aircraft engines, engine accessories, and APU rotating parts and assemblies. This type of testing creates a very dangerous environment in and around the Spin Pit test chambers. Only properly trained operators and technicians can perform this type of testing.

Due to the various types of testing performed in the RSF, some items of this checklist may not be required and should be annotated "N/A". Review the test directive and annotate or add to the checklist as necessary.

Review the test directive and identify all instrumentation and data acquisition items required for the particular test to be performed. Notify the instrumentation support branch for the set-up, calibration and the accomplishment of "end to end" checks for all required equipment prior to using this checklist.

CHECKLIST INSTRUCTIONS

1. All items of this checklist must be accomplished in sequence, unless identified "NA".
2. Review the emergency procedures for this test to performing any test cell or equipment operation.
3. The bold lettered terms, i.e. Warning, Caution and Note, will appear throughout this checklist and must be heeded. Each term will indicate the level of additional attention required before the accomplishment of the next checklist item or section. The following is an explanation of these terms:

****WARNING**** - A failure to heed a warning may result in personal injury or death if not carefully followed or observed prior to accomplishing the next item of the checklist.

****CAUTION**** - A failure to heed a caution may result in damage to equipment if not carefully followed or observed prior to accomplishing the next item of the checklist.

****NOTE**** - A note will draw attention to an essential point prior to accomplishing the next item of the checklist.

PRE-TEST SAFETY CHECKS

1. In the RSF Control Room, ensure that all three test chamber air control switches are in the "OFF" (center) position.
2. Turn on the test in progress light for spin pit #1, and the compressor in use light for room 71.

3. Perform a walk-through of all four spin chambers and ensure that the vacuum and compressed air manifolds are intact in all four chambers. Verify that the Main Air Valves (Yellow Ball Valve) is closed in all chambers. Verify that the vacuum manifold isolation valves, and the vacuum pump isolation valves are closed in all four chambers.

I. COMPRESSOR ROOM (Room 71)

****WARNING****

Approved hearing and eye safety protection must be worn at all times in the RSF's compressor room. Compressor air control lines are pressurized at all times, even with the RSF compressors not operating.

1. Notify [redacted] ([redacted]) or [redacted] ([redacted]) of the demand being placed on the process cooling water system prior to starting the compressor(s). Normal process cooling water system pressure is 35 to 75 PSI.

2. Ensure large red handled shop air supply valve in the compressor room is closed.

3. Inspect the compressor air receiver automatic condensate drain line for damage and that the automatic drain is operating.

4. Verify the exhaust louvers are open.

5. Verify the RSF air dryer ball valves are in the proper configuration. Refer to the drawing on the wall, or in the RSF Operators Guide. During normal operation when the PSEF shop air compressors are working properly, valves will be configured so that the RSF air compressor control air is supplied by the PSEF shop air compressors.

6. Utilize the Centac Compressor Checklist (located on the front of each compressor) to start the desired RSF compressor.

7. Verify compressor output is set to 125 psi, and that compressor is operating properly.

II. TEST CHAMBER AREA HOOKUP AND PRESTART

Section II of this checklist is accomplished after the test chamber lid, with the test article installed, is properly installed on the test chamber and all lines are connected

****WARNING****

Approved hearing and eye safety protection must be worn at all times in the RSF's test cell rooms and shop area.

Ensure that the drive turbine's compressed air supply line, manual ball valve (Yellow handle located near the proportional valve), and the condensate drain valve (located on the air pressure regulator), both remain closed when working around the test chamber or connecting/disconnecting the drive turbine drive or brake lines!

CAUTION

All hoses utilizing quick disconnects (QD) must be checked for positive engagement before pressurizing. This is accomplished by physically tugging on the hoses after connecting them.

1. Check the oil scavenge hose for positive QD engagement.
2. Check drive turbine bearing oil supply for positive QD engagement.
3. Check the damper oil supply hose for positive QD engagement.
4. Check all electrical connections for proper connection.
5. Verify the drive and brake air lines are properly connected and tight.
6. Verify the drive and brake air pressure indicator lines are properly connected and tight.
7. Verify the speed probe cannon plugs are properly connected and secure.
8. Verify the proximity probe cables are properly connected and secure.
9. Verify all thermocouple leads are properly connected and secure.
10. Verify that the heat exchanger cooling water valves are open for the heat exchanger on the drive turbine oil cart.
11. Verify that the drive turbine oil cart is plugged into the red wall receptacle and that the back-up compressed air line is connected.
12. Turn on the oil cart and verify flow in the oil flow gauges. Verify that bearing and damper oil pressures are both adjusted to 20psi.
13. Verify there are no oil leaks.
14. Close the spin pit vent valve.
15. Verify the valves for the vacuum pump pcw valves are open.
16. Utilize the vacuum pump checklist to start vacuum pump(s).
17. Start the RSF cooling loop in room 84. The specific start-up instructions are posted in room 84.
18. Ensure the proper entries are made in the Vacuum Pump logbook in the control room.
19. Open the PSEF shop air valve (located on top of the spin chamber on the wall).
20. Verify the balance air pressure is adjusted to value specified in the test plan.
21. If the vacuum pumps are properly warmed up, open the vacuum pump isolation valves and begin pulling vacuum.

III. CONTROL ROOM PRESTART:

1. Verify that the three toggle switches for the Main Air, Brake air, and Drive Air are still in the "Off" position.
2. Verify that the Pacific is configured for 6 tooth speed nut input. (first day of testing only).

3. Verify that the large tachometer is set to the proper overspeed alarm set point per the test plan.

4. Turn on the OpData computer and open the Pacific software. Click on "Display Definition" and open the operators screen. Click on Acquisition. Click on preview. Verify that Pacific Data is reading properly.

5. Power on the BSI computer and open the Spin IV software.

6. Click on "configuration" and select "test parameters" from the drop down menu. Verify limits are correct based on the test plan. **NOTE** If you have to change any values, you must hit enter after each value you change in order to save the change. When all parameters are correct, click on the "Download Edits" button.

7. Utilize the "configuration" drop down menu to select the "valve offsets" window.

8. Utilize the "status" drop down menu to open the "general status" window.

9. Utilize the "testing" drop down menu and open the "manual testing" window.

IV. FINAL TEST CELL CLOSE UP

1. In the test cell, open the large yellow main air supply valve.

2. In the test cell, double check all oil and water lines to ensure no leaks.

3. Clear the chamber of all personnel

4. Close and secure all test cell doors. Ensure outside doors are locked

5. Verify the "Test in Progress" light and the equipment in use lights are on for spin pit #1 and the compressor room. Visually verify all lights are operational.

6. Verify that the Astromed recorder is open to the correct file and that the green arrow is illuminated indicating strip chart operation.

7. Increment the Pacific Single Scan file and begin recording.

8. You are now set up and ready to test. Follow the procedures in the HCF operators guide and the test plan for specific instructions related to this test. Utilize this checklist for test shutdown and cell close-up at the completion of testing.

V. END OF DAY SHUTDOWN AND CELL SECURITY

1. Verify that test article RPM has reached "0" and place all three air control toggle switches in the "Off" position.

2. Stop the Astromed recorder and the Pacific Single Scan.

3. In the spin chamber, inspect the top of the spin lid for any signs of leaks or damage.

4. Close the PSEF Shop air valve to secure balance air.

5. Close yellow main air valve.

6. Close the vacuum pump isolation valves, and follow the vacuum pump checklist to turn off the vacuum pump(s).

7. Open the 2" ball valve to vent the spin chamber.
8. Turn off the cooling system in room 84.
9. Utilize the Centac checklist to turn off the RSF air compressors.
10. Secure the Drive Turbine Oil Cart and unplug the electric plug.
11. If testing is scheduled to continue the next day, it is not necessary to close any further valves.
12. Follow the instructions provided for disconnected and removing spin pit lid.
13. Turn off the "Test-In-Progress" and "Equipment-In-Use" lights.

Appendix F (Emergency Procedures)

The following procedures shall be followed for the emergency scenarios detailed below:

Scenario # 1: **Loss of speed control: Due to a problem with instrumentation or control hardware, the test article no longer responds to control inputs or safety limits.**

- **Stop Test**
  - Test Abort: Hit abort in the Spin IV software or the red abort button on the TC-4 twice to bring the speed to zero rpm.
  - Manual Mode: Centering the three speed control toggle switches will cut off air from the drive and brake lines. Toggling the main air and brake air switches to "Manual" will allow for a manually controlled deceleration to a stop.
  - Emergency Stop Button: If the other methods fail to stop the test article, the red E-Stop button on the control panel will prevent the rotor from continuing to accelerate (coast mode).
- **Troubleshoot Control Problem**

Scenario # 2: **Loss of Speed Indication: Due to an instrumentation problem, there are either no speed indications or the indications are different between the two probes.**

- **Stop Test**
  - Test Stop: Hit abort in the Spin IV software or the red abort button on the TC-4 to bring the speed to zero rpm.
  - Manual Mode: Centering the three speed control toggle switches will cut off air from the drive and brake lines. Toggling the main air and brake air switches to "Manual" will allow for a manually controlled deceleration to a stop.
  - Emergency Stop Button: If the other methods fail to stop the test article, the red E-Stop button on the control panel will prevent the rotor from continuing to accelerate (coast mode).
- **Troubleshoot Control Problem**