MAGIS – 100 Vacuum Bake Procedure

Document number: ED00

**Document Approval**

|  |  |
| --- | --- |
| Signatures Required | Date Approved |
| Author: Ron Kellett, Technical Support for MAGIS-100 |  |
| Co Author: Lucy Nobrega, Vacuum Engineer for MAGIS-100 |  |
| Co Author: Linda Valerio, Project Engineer for MAGIS-100 |  |
| Co Author: Noah Curfman, Mechanical Engineer for MAGIS-100 |  |
| Approver: Marty Murphy, Installation Coordinator for MAGIS-100  |  |
| Approver: Robert Plunkett, Project Manager for MAGIS-100 |  |

Revision History

|  |  |  |
| --- | --- | --- |
| Revision | Date of Release | Description of Change |
| - | TBD | Initial version |
|  |  |  |
|  |  |  |

Table of Contents

[1. PURPOSE 4](#_Toc68708446)

[2. SCOPE 4](#_Toc68708447)

[3. ACRONYMS 4](#_Toc68708448)

[4. REFERENCE 4](#_Toc68708449)

[5. EQUIPMENT and SERVICES REQUIRED 5](#_Toc68708450)

[5.1. Vacuum 5](#_Toc68708451)

[5.2. Control 5](#_Toc68708452)

[5.3. Overhead Crane Personnel Basket 5](#_Toc68708453)

[5.4. Records 5](#_Toc68708454)

[6. EQUIPMENT SETUP PROCEDURE 6](#_Toc68708455)

[6.1. Equipment Setup 6](#_Toc68708456)

[7. PRE-BAKE LEAK CHECK 6](#_Toc68708457)

[7.1. Leak Check the LD connection 6](#_Toc68708458)

[7.2. Evacuate Main Vacuum Tube and All Vacuum Sections 6](#_Toc68708459)

[7.3. Pre-bake Leak Check Entire Vacuum System 6](#_Toc68708460)

[8. VACUUM BAKE INSTRUCTIONS 7](#_Toc68708461)

[9. ETC. 7](#_Toc68708462)

[9.1. Self-Preservation Requirements 8](#_Toc68708463)

[9.2. Atom Source Protection Requirements 8](#_Toc68708464)

[9.3. Control & Diagnostics Requirements 8](#_Toc68708465)

[9.4. Installation and Integration Requirements 8](#_Toc68708466)

[9.5. Physical Placement 8](#_Toc68708467)

[10. Safety Requirements 8](#_Toc68708468)

[11. Quality Assurance 9](#_Toc68708469)

# PURPOSE

The MAGIS-100 experiment requires ultra-high vacuum to operate correctly. To achieve UHV a 150°C water bake will be necessary. This document describes the vacuum bake steps required for the MAGIS-100 vacuum tube and other components in the vacuum system.

# SCOPE

This document describes the correct procedure for performing a bakeout of the entire MAGIS-100 vacuum sector.

This document will cover the following topics:

* Equipment
* Bakeout setup
* Datalogging
* Leak checking
* Bakeout steps

Figure 1. INCLUDE IMAGES, CHARTS, GRAPHS HERE

# ACRONYMS

|  |  |
| --- | --- |
| MAGIS | Matter-wave Atomic Gradiometer Interferometric Sensor |
| FESHM | Fermilab Environment Safety & Health Manual |
| MINOS | Main Injector Neutrino Oscillation Search |
| UHV | Ultra High Vacuum |
| TC | Thermocouple |
| Sr | Strontium |
| LD | Leak Detector |
| RGA | Residual Gas Analyzer  |
| AMRAV | All Metal Right Angle Valve |
| ASBV | Anti-Suck Back Valves |
| ATM | Atmosphere  |

# REFERENCE

Follow all Travelers, HA directions, procedures and specifications associated with this procedure

* + List all HA’s, procedures and specifications here

|  |  |  |
| --- | --- | --- |
| **#** | **Reference** | **Document #** |
| 1 | Overhead crane personnel basket operation |  |
| 2 |  |  |

# EQUIPMENT and SERVICES REQUIRED

The following equipment is required to perform the MAGIS vacuum bake

## Vacuum

* Edwards 35i scroll pump (2) (needs updating)
* Turbo pump and controller (2)
* Fore-line hoses and anti-suck valves (enough for 2 stations)
* SRS RGA ?
* Leak detector capable of <2E-10 Torr L/sec sensitivity and remote
* Vacuum gauges and controllers (part of the vacuum system)

## Control

* SN UC controllers
* Connection to ACNET for control and datalogging
* WIFI connection and server connection
* Laptop computer with SRS RGA software installed

## Overhead Crane Personnel Basket

* Minimum of 2 crane operators (1 spotter), (1 operator) both crane certified to operate the personnel basket lift
* 2-way Radio communication
* Hands free cameras mounted on the basket for crane operator vision
* Lighting to allow good vision
* Reference personnel basket operation procedure and HA

## Records

Make e-log entries in the MAGIS-100 section of the elog website.

* Record all actions performed
* Record all problems encountered
* Datalog all gauges
* Datalog all pumps, if possible

# EQUIPMENT SETUP PROCEDURE

Follow the steps below in the order they are presented.

## Equipment Setup

* Connect all heaters to controllers
* Connect all TC’s to the proper controller associated with its matching heater
* Connect all controllers to the WIFI network
* Test each heater channel to ensure proper heater to controller connection and proper operation.
* Set the controllers to the proper temperature depending on maximum temp allowed per device
* Start software datalogging of vacuum gauges, controllers and TC’s
* Assemble all vacuum pumping station vacuum connections
* Close all turbo isolation right angle valves
* Connect leak detectors to the fore-line isolation valve (closed)

# PRE-BAKE LEAK CHECK

Follow the steps below in the order they are presented. BT is at ATM

## Leak Check the LD connection

* Ensure all vacuum connections have been made, no open ports in the beamline.
* Start leak detector and connect it to the ACNET datalogger
* Open leak detector isolation RAV
* Scroll pump ASBV is closed
* Using the LD, pump down each pumping station
* Leak check entire pump sub-assembly after leak detector reaches <2E-10 Torr L/sec
* Ensure ***no leaks*** are present before starting pump-down and bake, fix any leaks found
* Close the leak detector isolation RAV

## Evacuate Main Vacuum Tube and All Vacuum Sections

* Scroll pumps on (confirm operation ACNET),
* Open anti-suck back valves in pump down, switch to manual pump down mode (power outage still closes ASBV)
* Open the manual RAV turbo by-pass valve and then ***slowly*** open manual AMRAV’s
* Continue roughing until 100mTorr is reached in the BT.
* Turn on turbo’s
* Close RAV by-pass circuit’s (All pumping is through the turbo’s)
* Pump down and LC the LD hose, put LD in standby, open the LD RAV,
* If pressure permits, close the ASBV on the scrolls, all LD input through turbo’s

## Pre-bake Leak Check Entire Vacuum System

* After the LD sensitivity reaches 2E-10 Torr l/s, leak check the entire MAGIS assembly
* Fix all detectable leaks
* Isolate LD RAV
* Open anti-suck back valves on scrolls
* Make an RGA scan prior to bake

# VACUUM BAKE INSTRUCTIONS

Complete all previous sections before starting the bake by energizing the heaters. Always start the bake at the beginning of a shift to allow enough time for the heaters to reach set point temperature. Ensure all vacuum connections have been made, all ports filled in the beamline. E-log all vacuum data and personnel involved.

* The beamline must be under vacuum and being actively pumped with turbo’s
* Ensure vacuum gauges are being data logged. E-log pump down parameters, time, etc.
* Re-arm vacuum protection, turn on auto-protect mode (determine trip pressure)
* Continue pumping to a flat slope, record pressure before bake
* The chamber vacuum must be stabile before starting bake and data logged
* Make an elog entry of bake start time, record all vacuum data and personnel involved
* At the beginning of a shift, Turn on the heater controllers set at 150°C @ 2°/minute, datalogging all for temperature rise and slope capture
* Monitor pressure, temperature and pump performance, plot the pump down to help detect leaks that might occur during ramp up to 150°C @ 2°/minute
* Continually monitor heater progression, look for any runaway heaters, follow HA.
* Any indications of leaks must be investigated and fixed immediately, stop heating, leak check, fix leak.
* Continue pumping and baking until pressure drops equal to or lower starting pressure
* Turn off heaters
* Any indications of cool down leaks must be investigated and fixed, re-bake may be necessary.
* Turn on high vacuum pumps
* Isolate turbo pumping stations by closing AMRAV
* Remove vacuum equipment

# ETC.

|  |  |
| --- | --- |
| **Requirement #** | **Requirement Statement** |
| **2021-6448** | **MAGIS-100 Vacuum Bake Hazard Analysis - Form 2021-6448** |
|  | Personnel Basket Operation Procedure and HA |

1. Personnel Safety Requirements

|  |  |
| --- | --- |
| **Requirement #** | **Requirement Statement** |
| [FN000005/CR](https://www-esh.fnal.gov/pls/cert/schedule.show_course_details?this_course_code=FN000005&this_instr_type=CR&this_fermi_id=06600N) | Crane operator training |
| [FN000014/CR](https://www-esh.fnal.gov/pls/cert/schedule.show_course_details?this_course_code=FN000014&this_instr_type=CR&this_fermi_id=06600N) | Fork truck operator training |

## Self-Preservation Requirements

|  |  |
| --- | --- |
| **Requirement #** | **Requirement Statement** |
| [FN000380/CR](https://www-esh.fnal.gov/pls/cert/schedule.show_course_details?this_course_code=FN000380&this_instr_type=CR&this_fermi_id=06600N) | NuMI/MINOS Underground Safety Training |

## Atom Source Protection Requirements

|  |  |
| --- | --- |
| **Requirement #** | **Requirement Statement** |
|  |  |

## Control & Diagnostics Requirements

|  |  |
| --- | --- |
| **Requirement #** | **Requirement Statement** |
|  |  |

## Installation and Integration Requirements

|  |  |
| --- | --- |
| **Requirement #** | **Requirement Statement** |
|   |  |

## Physical Placement

|  |  |
| --- | --- |
| **Requirement #** | **Requirement Statement** |
|   |  |
|  |  |
|   |  |

# Safety Requirements

The system shall abide by all Fermilab ES&H (FESHM) and all Fermilab Radiological Control Manual (FRCM) requirements including but not limited to:

|  |
| --- |
| Structural Safety |
| * FESHM Chapter 5100 Structural Safety
 |
| Electrical Safety |
| * FESHM Chapter 9110 Electrical Utilization Equipment Safety
 |
| * FESHM Chapter 9160 Low Voltage, High Current Power Distribution Systems
 |
| * FESHM Chapter 9190 Grounding Requirements for Electrical Distribution and Utilization Equipment
 |
| General Safety |
| * FESHM Chapter 2000 Planning for Safe Operations
 |

1. Any changes in the applicability or adherence to these standards and requirements require the approval and authorization of the PIP-II Technical Director or designee.
2. In addition, the following codes and standards in their latest edition shall be applied to the engineering, design, fabrication, assembly and tests of the given system:

|  |
| --- |
| FCC OET Bulletin 65, Edition 97-01 ANSI ASC A14.3-2000 Safety Requirements for Fixed Ladders |
| NFPA 70 – National Electrical Code |
| IEC Standards for Electrical Components |

1. In cases where International Codes and Standards are used the system shall follow FESHM Chapter 2110 Ensuring Equivalent Safety Performance when Using International Codes and Standards and requires the approval and authorization of the PIP-II Technical Director or designee.
2. Additional Safety Requirements that are not listed in the general list above shall be included in the Requirements table in the Functional Requirements section.
3. Any changes in the applicability or adherence to these standards and requirements require the approval and authorization of the PIP-II Technical Director or designee.

# Quality Assurance

|  |  |
| --- | --- |
| **Requirement #** | **Requirement Statement** |
|   | The critical geometric data --- ???---- should be measured by Fermilab survey group to the accuracy of 0.05”or less before the start of final system assembly. |
|  |  |

1. The magnetically shielded modular sections have redundant heaters preinstalled in case of heat tape failure.
2. All critical devices (heaters) used in the bakeout system should be tested before being covered by magnetic shielding to ensure operation. (Do not take the heater past 30°C in testing)
3. The heater temperatures are controlled by Fermilab designed controllers to prevent damage to system.