

# ASSEMBLY OF ATLAS POWER FLOW CHANNEL \*

M. Salazar, S. Feng<sup>ξ</sup>, J. Griego and P. Reardon

Polymers and Coatings Group, MST-7  
Material Science and Technology Division  
Los Alamos National Laboratory  
Los Alamos, NM 87545, USA

## Abstract

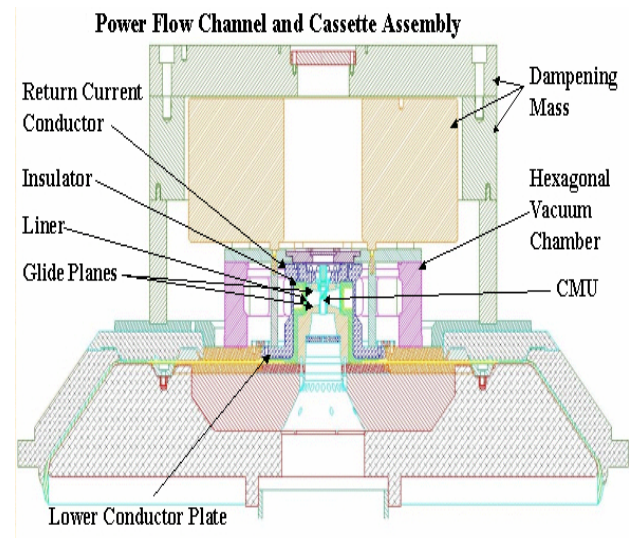
Assembly of the Atlas Power Flow Channel (PFC) containing the target cassette was a difficult operation prior to moving the machine to the Nevada test site (NTS). The assembly operation consisted of the target cassette manufactured at the Target Fabrication Facility of Los Alamos National Laboratory (TFF), vacuum containment hardware, and the PFC. The combination was made up of approximately 317 separate components that were required to fit accurately and become vacuum tight. The assembly process also included wired diagnostic feed through and x-ray diagnostic components inside the vacuum containment. All this activity occurred for each experiment on the deck of the Atlas machine. Each experiment altered the position of the conductor plates due to the dynamic forces of the electrical and magnetic pulse causing each subsequent installation to be unique with its own unique problems. An evolutionary design for the Atlas vacuum envelope (VE) eliminates the fit problems on the machine and reduces components assembled on the Atlas deck to one vacuum envelope assembled in a laboratory consisting of approximately 223 parts, and one part for mating to the PFC. The original Atlas PFC had a pumped volume of approximately 37.7 liters. The VE has a pumped volume of approximately 0.8 liters.

## I. INTRODUCTION

The evolutionary design of the VE for Atlas at the NTS addresses many of the issues associated with the previous designs [1] as shown in Fig 1. Much of the Atlas assembly involved vacuum components, wired and fiber optic diagnostic feed through, and x-ray diagnostic components inside the vacuum containment.

The joints connecting the liner/glide plane assembly of the Atlas design [2] are a hard bolted design that has no accommodation in the vertical direction. The cryogenic fit liner/glide plane joints of the previous design separate easily because of the Atlas power flow channel non-uniformity. These joints relied exclusively on the inference of the glide plane/liner interface for electrical conductivity and structural integrity. Slipping the liner on the glide planes accommodates

deviation in the vertical direction. This displacement adversely affected some experiments. The fabrication of the glide plane/liner of the Atlas design interface could not yield predictable assembly results.



**Figure 1.** Old style Atlas PFC and Cassette assembly were used when the Atlas machine was located at Los Alamos National Laboratory.

Assembly of the VE (Fig. 2) is now a mechanically interfered joint type eliminating the cryogenic fit of precision components. The upper liner/glide plane interface joint [3] described uses wedging interference to securely join the glide plane, liner and return conductor into a strong assembly.

The lower liner/current joint [4] eliminates one of the cryogenic interfered joints. The lower liner/current joint also uses wedging interference to secure the hardware together. This different joint design allows a large accommodation of the separate components in the axial direction. This joint type is used in three places.

The Cassette is the now VE. This eliminates the Hex Chamber with its many penetrations. The Hex Chamber is replaced with the Hex Pipe, a very simple lattice pipe

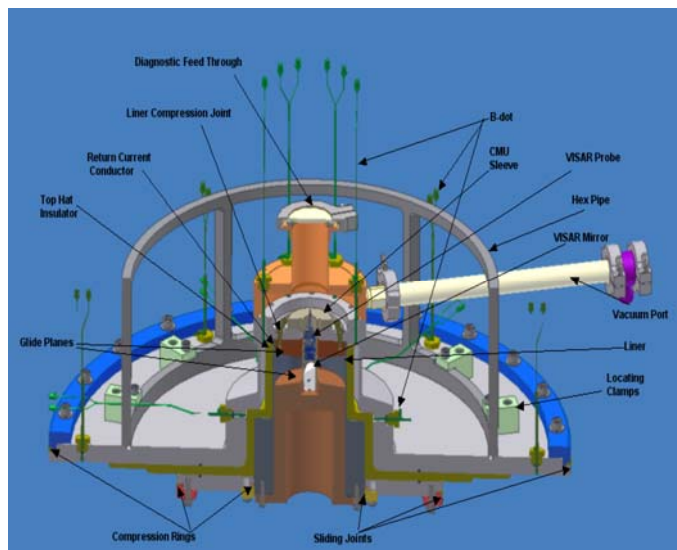
\* Work supported in part by the US Dept of Energy under contract number W7405-ENG36(LA-UR 05-4262)

<sup>ξ</sup> email: sfeng@lanl.gov

| Report Documentation Page                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                    |                                     |  | Form Approved<br>OMB No. 0704-0188       |                                 |                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-------------------------------------|--|------------------------------------------|---------------------------------|---------------------------------|
| Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                    |                                     |  |                                          |                                 |                                 |
| 1. REPORT DATE<br><b>JUN 2005</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                    | 2. REPORT TYPE<br><b>N/A</b>        |  | 3. DATES COVERED<br><b>-</b>             |                                 |                                 |
| 4. TITLE AND SUBTITLE<br><b>Assembly Of Atlas Power Flow Channel</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                    |                                     |  | 5a. CONTRACT NUMBER                      |                                 |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |  | 5b. GRANT NUMBER                         |                                 |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |  | 5c. PROGRAM ELEMENT NUMBER               |                                 |                                 |
| 6. AUTHOR(S)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                     |  | 5d. PROJECT NUMBER                       |                                 |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |  | 5e. TASK NUMBER                          |                                 |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |  | 5f. WORK UNIT NUMBER                     |                                 |                                 |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><b>Polymers and Coatings Group, MST-7 Material Science and Technology Division Los Alamos National Laboratory Los Alamos, NM 87545, USA</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                    |                                     |  | 8. PERFORMING ORGANIZATION REPORT NUMBER |                                 |                                 |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                    |                                     |  | 10. SPONSOR/MONITOR'S ACRONYM(S)         |                                 |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |  | 11. SPONSOR/MONITOR'S REPORT NUMBER(S)   |                                 |                                 |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release, distribution unlimited</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                    |                                     |  |                                          |                                 |                                 |
| 13. SUPPLEMENTARY NOTES<br><b>See also ADM002371. 2013 IEEE Pulsed Power Conference, Digest of Technical Papers 1976-2013, and Abstracts of the 2013 IEEE International Conference on Plasma Science. IEEE International Pulsed Power Conference (19th). Held in San Francisco, CA on 16-21 June 2013., The original document contains color images.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                    |                                     |  |                                          |                                 |                                 |
| 14. ABSTRACT<br><b>Assembly of the Atlas Power Flow Channel (PFC) containing the target cassette was a difficult operation prior to moving the machine to the Nevada test site (NTS). The assembly operation consisted of the target cassette manufactured at the Target Fabrication Facility of Los Alamos National Laboratory (TFF), vacuum containment hardware, and the PFC. The combination was made up of approximately 317 separate components that were required to fit accurately and become vacuum tight. The assembly process also included wired diagnostic feed through and x-ray diagnostic components inside the vacuum containment. All this activity occurred for each experiment on the deck of the Atlas machine. Each experiment altered the position of the conductor plates due to the dynamic forces of the electrical and magnetic pulse causing each subsequent installation to be unique with its own unique problems. An evolutionary design for the Atlas vacuum envelope (VE) eliminates the fit problems on the machine and reduces components assembled on the Atlas deck to one vacuum envelope assembled in a laboratory consisting of approximately 223 parts, and one part for mating to the PFC. The original Atlas PFC had a pumped volume of approximately 37.7 liters. The VE has a pumped volume of approximately 0.8 liters.</b> |                                    |                                     |  |                                          |                                 |                                 |
| 15. SUBJECT TERMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                    |                                     |  |                                          |                                 |                                 |
| 16. SECURITY CLASSIFICATION OF:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                     |  | 17. LIMITATION OF ABSTRACT<br><b>SAR</b> | 18. NUMBER OF PAGES<br><b>4</b> | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT<br><b>unclassified</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b> |  |                                          |                                 |                                 |



structure. The entire Vacuum Envelope is assembled in the laboratory at TFF. Its diagnostics are installed and the entire system is vacuum leak checked. This single sealed unit is installed at Atlas/NTS.



**Figure 2.** New style Atlas VE reduces number of components.

## II. VACUUM

The previous Atlas PFC vacuum may not have been as good as quoted due to the large volumes, material out gassing, long plumbing runs, and the remoteness of the gauging. Testing of the VE system that has much less volume, less surface area to outgas, short plumbing runs, and close gauging shows that a vacuum of no less than  $5E-5$  Torr can be achieved. Testing has revealed that out gassing exists in the VE design. A very tight leak system does not ensure that a good vacuum can be sustained without pumping. During vacuum testing it has become apparent that the vacuum in the test volume will rise quickly without continuous pumping. An auxiliary pump will be placed in line to run after mechanical pumps have been isolated.

## III. HEX PIPE

The Hex Pipe is a simple lattice structure and takes the place of the Hex Chamber of the previous design. The replacement of the Hex Chamber decreases vacuum volume and the many vacuum seals associated with windows and bonded diagnostic penetrations. The current design is shown in Fig. 3. The Hex Pipe is an inexpensive water jet machined item. The Hex Pipe

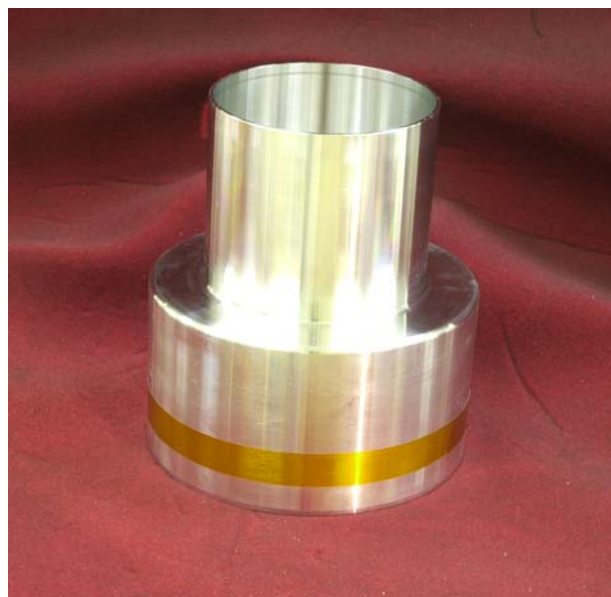
is a load carrying member used for lifting and for supporting the weights of the finished test assembly. The large openings allow better access to the experiment for placement of diagnostics.



**Figure 3.** Atlas Hex Pipe is used for lifting the assembly and supporting weights.

## IV. LINER

The new liner design is much longer. It is, however, much simpler to machine. The cryogenic fit of liner to glide plane has been eliminated. The upper joint uses mechanical wedging of the upper Glide Plane/Liner/Return Current Conductor into a single unit. The lower joint uses a different wedging system to assure electrical contact and structural integrity and the ability to accommodate vertical non-uniformity.



**Figure 4.** New Lines design for liner

## V. RETURN CURRENT CONDUCTOR

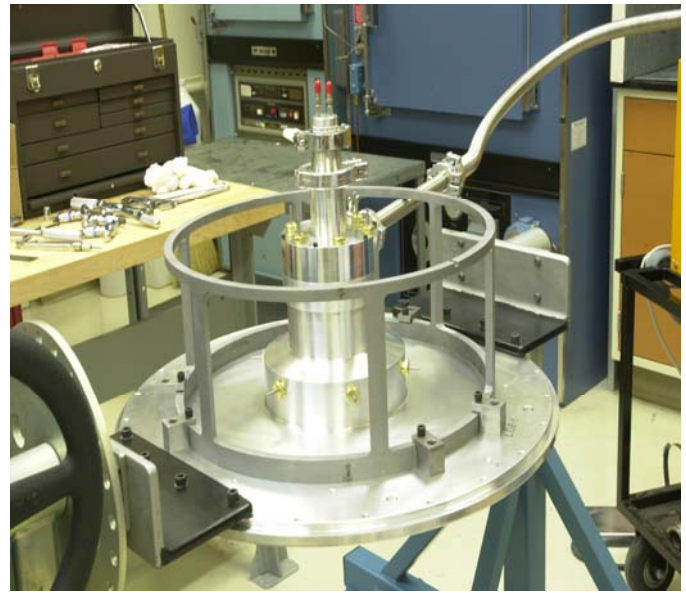
The Return Current Conductor (RCC) becomes the vacuum vessel. The vacuum volume of the new design is much less than the old design. The diameter of lower section of this component has increased from 14.39" to 27.7". This increase eliminates a current joint and the associated hardware. Penetrations for diagnostics are accommodated at this level by easily sealed o-ring type compression fittings. The alignment of target load to RCC is done by asymmetric mounting holes. Rotational indexing is fixed by locating holes to the Atlas power flow channel. These features insure the exact alignment of diagnostics to the target load and the PFC. The Return Current Conductor is shown in Fig. 5.



**Figure 5.** Atlas Return Current Conductor shows the increased diameter

## VI. VACUUM ENVELOPE

The entire VE is assembled in the laboratory at TFF. The diagnostics are installed and the entire system is vacuum leak checked. This single sealed unit is installed at Atlas/NTS. As shown in Fig. 6, the VE is installation consists of only one part.



**Figure 6.** The complete Atlas vacuum envelope.

## VII. CONCLUSION

Atlas Vacuum Envelope redesign has enabled the pumped volume to be reduced to approximately 2% of the old style. The total parts count of the VE is approximately 70% of the PFC. The parts assembled on the deck of Atlas are about 14% of the previous design. This extensive effort allows a more efficient and effective installation of the VE, faster turn around between experiments, and machine variability. Load vacuum and diagnostic issues can be solved in the lab as opposed to on deck. The VE can be readily redesigned to meet physics needs in both diameter and height.

Application of these techniques allows Atlas targets to be designed that are pressurized and subject to significant static load. These targets might contain liquid or gas in concentric layers. The residual stress analysis in conjunction with finite element analysis is assisting designing targets and target systems that are less massive, thus allowing experiments to be optimized and produce better diagnostic clarity.

## ACKNOWLEDGMENT

The authors would like to thank Dr. Patrick Reardon for his thoughtful advice and discussion. We are also grateful to Dr. Shihai Feng for his assistance with the manuscript preparation. We are in debt to the staff in MST-7 for their kind help and assistance.

## REFERENCES

- [1] M. Salazar, W. Atchison, R. Faehl, and R. Reinovsky  
“Advanced Cassette Liner Assembly for Atlas,”  
*2002 Megagauss 9 Meeting Moscow, RU*
- [2] W. Anderson, et. al. “A Proposed Atlas Liner Design  
Fabrication for Hydrodynamic Experiments on Shiva  
Star,” Los Alamos National Laboratory, Los Alamos, New  
Mexico, 87545, U.S.A
- [3] M. Salazar, et. al. “Atlas Liner Cassette Lower Power  
Flow Channel Interface” to be published in *Conf. Rec.2005  
IEEE Int. Conf. Communications.*
- [4] M. Salazar, et. al. “Atlas Liner Cassette Upper Power  
Flow Channel Interface” to be published in *Conf. Rec.2005  
IEEE Int. Conf. Communications.*
- [5] M. Salazar, et. al., “Fabrication of High Energy Density  
Physics Loads for Atlas,” report Los Alamos National  
Laboratory, Los Alamos, NM 87545, USA
- [6] M. Salazar, et. al., “Target Development at Atlas,” to be  
published in *Conf. Rec.2005 IEEE Int. Conf.  
Communications.*