Experience with Testing and Application of Cable-In-Conduit Conductors (CICC)

FRIDAY, SEPTEMBER 24, 1993
VICTORIA CONFERENCE CENTRE
VICTORIA, B.C.

SPONSORED BY BECHTEL AND THE NATIONAL HIGH MAGNETIC FIELD LABORATORY

02485

Experience with Testing and Application of Cable-in-Conduit Conductors (CICC)

Friday, September 24, 1993

Victoria Conference Centre
Victoria, B.C.

Workshop Introduction

Historically, cable-in-conduit conductors (CICCs) were developed as a solution to the difficult problems facing designers of large superconducting magnets for fusion, among whom their acceptance is now essentially universal. The concept simultaneously offers attractive options for fabrication simplicity, inherently low losses in transient fields, predictably high stability margin, positive removal of background heating, distributed structure for intercepting electromagnetic loads at their source, and last but not least, simplified helium containment. Recently, the CICC concept is finding application in areas other than fusion as variations on the theme have been proposed for such projects as the Engineering Test Model for Superconducting Magnetic Energy Storage (SMES-ETM), the superconducting solenoid for GEM, a large detector magnet for SSC, and for the superconducting outsert magnet of the 45-T Hybrid Magnet System being installed at the National High Magnetic Field Laboratory (NHMFL).

The fact that CICCs are being proposed for such divergent applications points to the versatility and potential offered by the concept. It is true, however, that many of these applications never survive the development and design phases (such is the case with GEM and with the 20 MWh SMES-ETM). Such programs encounter their fate despite significant successes in their CICC development and test programs. CICC technology has matured significantly in the last 20 years, yet the perception is still that CICCs are an emerging concept. This erroneous perception may stem from the absence of a completed large magnet system based on CICCs, a consequence more of funding woes than of technical issues. As a contribution towards removing this misconception, a one-day workshop focusing on the experience testing CICCs was organized and held in conjunction with the MT-13 Conference, in Victoria, B.C.. Some of the world's most recognized experts on CICC technology participated in the workshop. The material presented at the workshop is included in this volume, along with selected papers based on the work discussed. The volume covers a large fraction of the test experience with CICCs, yet a lot more remains to be reviewed in areas such as analysis, design, and fabrication.

This workshop was the second in a series started last May at NHMFL, when a similar, yet smaller meeting was held to discuss advances in computer simulation of quench in CICC magnets. The NHMFL has both a general interest (by virtue of its mission to support advanced magnet development) and a special interest (by virtue of its goal to produce in 1995 a successful 45-T hybrid facility) in supporting these workshops. Likewise, Bechtel is interested in advancing CICC technology both with the specific case of SMES in mind (the Bechtel Team's SMES design is based on the CICC concept), and in general, to disseminate knowledge in the industrial base. Many of the large-scale magnets to come on-

line in the near future (not only a SMES demonstration, but also TPX and ITER) will be built by industry, and the wealth of experience residing in the national laboratories and universities needs to be transferred to the private sector for such projects to succeed.

It is hoped that this and future workshops will serve as vehicles for a strong interaction among workers in the field of CICC technology. One of the objectives is the acceleration of the already impressive progress through timely information exchange and by eliminating duplication of efforts in institutions around the world.

John R. Miller
National High Magnetic Field Laboratory

Cesar A. Luongo
Bechtel, Research & Development

Experience with Testing and Application of Cable-in-Conduit Conductors (CICC)

Friday, September 24, 1993

Esquimalt Room
Victoria Conference Centre
Victoria, B.C.

Workshop Agenda

8:00AM	C.A. Luongo (Bechtel)	Welcome/Opening Remarks
8:05AM	J.R. Miller (NHMFL)	Overview of Past CICC Tests
8:30AM	J. Minervini (MIT)	CICC Experience at MIT
8:55AM	P. Sanger (Westinghouse)	Summary of Tests for the Westinghouse LCP Conductor and Joints
9:30AM	J.W. Lue (ORNL)	Experience with CIC Magnets at ORNL
9:55AM		Break
10:05AM	S. Shen (LLNL)	High-Field Tests of ITER Prototype CICC
10:30AM	T. Mito (NIFS)	Development of Forced-Flow Cooled Super-conducting Poloidal Coils for Large Helical Device
10:55AM	S.D. Peck (General Dynamics)	Lessons Learned from Testing the SMES CICC - Adventures at 200 kA and Above
11:20AM	J.R. Miller (NHMFL)	Quench Initiation and Propagation Study for the SMES CICC

Workshop Agenda
(Continued)

11:45AM		Lunch
1:00PM	J.L. Duchateau (CEA)	Presentation of CEA Activity on CIC Development for Fusion
1:25PM	R. Heller (KfK)	Status of the Conductor Development for the Stellarator Wendelstein 7-X
1:50PM	T. Ando (JAERI)	Test Results on CICCs and Coils Fabricated as part of the Development of Fusion Magnets at JAERI
2:15PM	C. Schmidt (KfK)	Stability of CIC Conductors in Rapidly Changing Magnetic Fields: Experiments and Model Calculations
2:40PM	A. Bonito-Oliva (Ansaldo/NHMFL)	Development Experience at Ansaldo in CIC Conductors
3:05PM		Break/Adjourn
3:15PM	All speakers	Planning for preparation of review paper and assignment of tasks.

SPEAKERS

Toshinari Ando
Superconducting Magnet Laboratory
JAERI
Naka-Machi, Naka-gun
Ibaraki, 311-01
JAPAN
FAX: 011-81-292-707579

Jean-Luc Duchateau
Commissariat a L'Energie Atomique
Centre d'Etudes Nucleaires de Cadarache
St. Paul Lez Durance, Cedex 13108
FRANCE
FAX: 011-33-42254990

Reinhard Heller
Kernforschungszentrum Karlsruhe GmbH
Institute für Technische Physik
Postfach 3640
D - 76021, Karlsruhe
GERMANY
FAX: 011-49-7247-822849

Winston Lue
Oak Ridge National Laboratory
P.O. Box 2009
Bldg. 9105, MS 8040
Oak Ridge, TN 37831-8040
FAX: 615 574-0584

John R. Miller
National High Magnetic Field Laboratory
1800 E. Paul Dirac Dr.
Tallahassee, FL 32306-3016
FAX: 904 644-5038

Joseph V. Minervini
MIT
Plasma Fusion Center
Cambridge, MA 02139-4307
FAX: 617 253-0700

SPEAKERS

Toshiyuki Mito
National Institute for Fusion Science
SCM & Cryogenic Building
Oroshi-cho, Toki-shi
Gifu-ken, 509-52
JAPAN
FAX: 011-81-572-577465

Alessandro Bonito-Oliva
National High Magnetic Field Laboratory
1800 E. Paul Dirac Dr.
Tallahassee, FL 32306-3016
FAX: 904 644-5038

Scott Peck
General Dynamics Space Systems Division
P.O. Box 85990
M/Z CP-9540
San Diego, CA 92186-5990
FAX: 619 547-8350

Phillip Sanger
Westinghouse Electric Corp.
Science & Technology Center
1310 Beulah Rd.
Pittsburgh, PA 15235
FAX: 412 256-1948

Curt Schmidt
Kernforschungszentrum Karlsruhe GmbH
Institute für Technische Physik
Postfach 3640
D - 76021, Karlsruhe
GERMANY
FAX: 011-49-7247-822849

Stewart Shen
Applied Superconductivity Group
Lawrence Livermore National Laboratory
P.O. Box 808, L-643
Livermore, CA 94550
FAX: 510 422-2477

PARTICIPANTS

William Bingham
Bechtel
P.O. Box 193965
San Francisco, CA 94119-3965

Mark Bird
National High Magnetic Field Laboratory
Florida State Univeristy
1800 E. Paul Dirac Dr. B-223
Tallahassee, FL 32306

Bertrand Blau
Paul Scherrer Institute
MH / C 23
Villigen, PSI 5232
SWITZERLAND

Luca Bottura
The NET Team c/o Max Planck IPP
Boltzmannstr. 2
D - 8046, Garching
GERMANY

Pierluigi Bruzzone
The NET Team c/o Max Planck IPP
Boltzmannstr. 2
D - 8046, Garching
GERMANY

Ales Bulc
Bechtel
P.O. Box 193965
San Francisco, CA 94119-3965

Gary Deis
SSC Laboratory
2550 Beckleymeade Ave
Bldg. 4 MS 2005
Dallas, TX 75237

Henri Desportes
CEA SACLAY - SCTM
Gif sur Yvette, 91191
FRANCE

PARTICIPANTS

Alan Devernoe
Intermagnetics General Corp
P.O. Box 5566
Guilderland, NY 12084

Oriano Dormicchi
Ansaldo GIE
Via N. Lorenzi 8
Genova, 16152 ITALY

William Hassenzahl
Applied Superconductivity Group
Lawrence Livermore National Laboratory
P.O.Box 808, L-643
Livermore, CA 94551

Victor Keilin
Russian Research Center
Kurchatov Institute
123182, Moscow
RUSSIA

Peter Komarek
Kernforschungszentrum Karlsruhe GmbH
Institute fur Technische Physik
Postfach 3640
D - 76021, Karlsruhe
GERMANY

Dwight Lang
Lawrence Livermore Nat'l Lab
P.O. Box 808 L-636
Livermore, CA 94550

Paul Libeyre
Association Euratom CEA
CE Cadarache DRFC/STIF
St. Paul Lez Durance, Cedex 13108
FRANCE

Dennis Lieurance
General Dynamics
Space Systems Division
P.O. Box 85990 M/Z C1-9540
San Diego, CA 92186-5990

PARTICIPANTS

Cesar Luongo
Bechtel
P.O. Box 193965
San Francisco, CA 94119-3965

Peter Marston
MIT
Plasma Fusion Center
Cambridge, MA 02139-4307

Tom Painter
National High Magnetic Field Laboratory
Florida State University
1800 E. Paul Dirac Dr. B-223
Tallahassee, FL 32306

Ken Partain
Bechtel
P.O. Box 193965
San Francisco, CA 94119-3965

Gabriel Pasztor
Paul Scherrer Institute
MH / C 25
Villigen, 5232
SWITZERLAND

Lawrence Pedrotti
Lawrence Livermore Nat'l Lab
7000 East Ave L532
Livermore, CA 94550

Hans Schneider-Muntau
National High Magnetic Field Laboratory
Florida State University
1800 E. Paul Dirac Dr. B-223
Tallahassee, FL 32306

Sharad Singh
Westinghouse Electric Corp.
Science & Technology Center
1310 Beulah Rd.
Pittsburgh, PA 15235

PARTICIPANTS

Brad Smith
MIT / Plasma Fusion Center
185 Albany St., NW22-257
Cambridge, MA 02139

Maurizio Spadoni
ENEA
Cre Frascati CP 65
Frascati, 00044
ITALY

Michael Steeves
MIT
Plasma Fusion Center
Cambridge, MA 02139-4307

Richard Thome
JAERI-Iter Eda Work Site
801-1 Mukoyama
Naka-Machi, Naka-gun
Ibaraki-ken, 311-01
JAPAN

Steve Van Sciver
National High Magnetic Field Laboratory
Florida State University
1800 E. Paul Dirac Dr. B-223
Tallahassee, FL 32306

Georg Vecsey
Paul Scherrer Institute
Villigen, PSI/AG 5232
SWITZERLAND

Robert Wilcox
Intermagnetics General Co.
P.O. Box 566
Guilderland, NY 12084

John E. C. Williams
Francis Bitter National Magnet Lab.
MIT
170 Albany St.
Cambridge, MA 02139-4307