# §4. Directory on Recent Information about Operational Experiences on Large Superconducting and Cryogenic System in Fusion and Particle Accelerator

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i) PURPOSE

The research is intended to collect and evaluate the newest operational technology and safety management methodology in the relevant field. This enables us to develop a world common technical standard and also to indicate its importance to the public.

ii) PROCEDURE

From FY 2011. the main work has been continued to collect the past 20 year's research papers published at several international conferences such as ICEC, ACE, FED, IEEE (App.Super. and Magnet Tech.) and several additional papers. The collected papers were firstly classified according to institution / device of author, secondly written in a PC data base on device specification and title list using Microsoft Excel table. The tables contribute to facilitate annual addition / revision work by the author. Thirdly, combine the indices into one Excel table and transform it into a Filemaker-PRO table in order to facilitate key word query search. Since the data base includes similar information on particle accelerator / collider, the present two expertise were asked to join the research and to supervise from the current FY 2012.

iii) PROGRESS IN FY 2012

Since every paper is published only several months after the presentation has made, about 150 papers from FY 2011 publications were collected during FY 2012. This summed up to about 800 on cryogenic system and 130 on magnets (since 2006) in total. Also summary tables were written as addition to the previous tables. The numbers of the device / institution are counted to about 100. As described above, they can be inquired by a key word query survey, several sample surveys are made according to key words of stored energy mega Joule: MJ, colliding energy electron Volt: eV and 4 K He refrigeration capacity: kW and of which result are shown in the Table 1 by a number of relevant device in three fields i.e. fusion, accelerator and other. The result indicates that the data base contains 11, 37 and 42 events corresponding to each key word above and 2/3 out of 42 kW-class helium cryogenic systems contribute to accelerators. In addition to a number of events, summery information for each event is also obtained at the same time because a set of other information such as device / component specification, operation history, institution and published papers is attached to every event so that a comparative survey can be made among resulted key word query events.

iv) SURVEY over recent reports on failure and reliability analysis

Among the collected papers several reports of the 21st century are briefly surveyed here. NIFS (fusion, Japan) renews it's reliability data on LHD thru. 15 year's operational experience (1). 26 down events during 67,278 net operation hour were experienced, i.e. availability of 99.1% has been achieved. KEK (accelerator, Japan) developed a WWW data base for cryogenic system using failure data at 4 domestic institutions (2-1,-2). Although the work was completed at 2007, data collection is still continued by Cryopt workshop. In 1986 Doi Y (KEK) presented data on MTBF (mean time between failure) and MTTF (mean time to repair) about SKS and TRISTAN (2-3). Stanford (accelerator US) reports 6 years experience and failure data on BABAR-B factory (3). Fermi (accelerator US) achieved a record of 20 years operation and reported it's analysis on down time (4). Brookhaven (accelerator US) counts 5 years heavy ion colliding experiment (6). Others reported are ISAC-II (accelerator Canada (7)) and OPAL (accelerator Australia (10-1,-2). LHC (accelerator CERN (9-1,-2)) had a serious accident by the initial magnet exciting on September 2008 due to a short circuit current at a feed through. It took more than one year down time before the first physics experiment can be made. In the mean time, efforts were made to estimate occurrence and severity of- and in order to reduce failure of- each device and instrument using existing failure data base. A Computer Aided Maintenance Management System (CAMMS) was developed and 95% availability during one year after the restart in 2010 was attained. Since MTBF corresponds to stability (failure occurrence) and MTTR corresponds to down risk (failure severity), if we assign an individual running- / failure down- time (hr) onto several ranked class of seriousness, then a former class multiplied by the latter class makes a criticality function value. An evaluation of the criticality value can be made by plotting it on the occurrence- and severity- coordinate map in which the permissible criticality domain is predetermined. ITER organization (fusion ITER-organization) developed Reliability, Availability, Maintainability and Inspectional ability (RAMI) analysis and applied the results to a whole device design and construction of ITER (9-1,-2). Linear- / Storage- ion accelerator make use of super conducting resonant frequency cavity. An international collaborating research on design procedure of cavity and safety relief rupture disc against Sudden Catastrophic Loss of Vacuum (SCLV) accident has been proceeded (11, 12-1,-2) for ILC (accelerator Fermi). At 11th March 2011 a bottom of Pacific coast originated huge earthquake and following Tsunami waves hit the North-Eastern part of Japan island. Measured maximum local acceleration (horizontal) are 550 Gal at Fukushima #1 nuclear power station and 530 Gal at Ibaraki prefectural government which is 4 km apart from J-PARC (accelerator KEK). These did not exceed 818 Gal at Kobe on17th Jan. 1995 and so were the damage to structures if architectures washed by Tsunami are excluded. A report on the event at J-PARC was made (13). A damages on the 282 tons SKS superconducting dipole magnet (not excited) and it's cryocooler systems are described. A 77 mm sideslip of the heavy iron yoke and 6 support bolt's cut were observed, also all of the beam line support bolt were found dropped-off from the wall. Fortunately any damage at fragile HTC current leads and GFRP supports was not observed. After 10 months restoration work the physics experiment restarted on Feb. 2012.

Since our data base includes the separate lists of the past papers on each device / institution, other information than the summary data is traceable by searching the list for the title of desired paper and then referring to the original copy according to the abbreviations of the book.

A detail information on the data base is available at the author's home page http:// www.eonet.ne.jp/~nifs-satosada/ END

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**Table 1. Query number to three different keywords**

| key word | | total | Fusion | Accelerator | other |
|---|---|---|---|---|---|
| stored energy | **MJ** | 11 | 8 | 2 | 1 |
| colliding energy | **eV** | 37 | 3 | 33 | 1 |
| 4Krefrigeration | **kW** | 42 | 13 | 27 | 2 |

(1) Mito T et al : ICEC24 (2012) 449, (2-1) Haruyama T et al. : ACE51A (2005) 1369, (2-2) Aoki K et al : ICEC21 (2006) 219, (2-3) Doi Y et al : ICEC11 (1987) 520, (3) Thompson E et al : ACE51A (2005) 71, (4-1) Theilacker J C : ACE49A (2003) 139, (4-2) Martinez A et al : ACE57A (2011) 1123, (5) Haberstroh Ch et al : ICEC21 (2006) 252, (6) Than R(BNL),, Arenius D(CEBAF) et al : ACE53A (2007) 578, (7) Sekachev I et al : ACE53A (2007) 1580, (8-1) Lebrun Ph : ICEC23 (2010) 41, (8-2) Brodzinski K et al : ibid 871, (8-3) Chorowski M et al : ibid 879, (8-4) Wach J : ibid 905, (8-5) Perniç G et al : ACE57A (2011) 1399, (8-6) Delruelle N et al : ibid 86, (9-1) Henry D et al : ibid 1551, (9-2) Chrowski M et al : ibid 1559, (10-1) Lu W et al : ACE57A (2011) 1537, (10-2) Thiering R et al : ACE57A (2011) 1543, (11) authors of Fermi, KEK, DESY and CEBAF : ACE57A (2011) 1575, (12-1) authors of NHMFL, Texas A&M U., Houston ARC, LLC : ACE57A (2011) 309, (12-2) Dalesandro A(FERMI) and VanSciever SW (NHMFL) : ACE57A (2011) 1567, (13) Aoki K et al : ICEC24 (2012) 497.