Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia

Report of the

Malé Declaration Training Workshop on Evaluation of Corrosion Attacked on Materials

09 – 11 October 2006

UNEP Regional Resource Centre for Asian and the Pacific

Thailand

October 2006

Malé Declaration Training Workshop on Evaluation of Corrosion Attack on Materials

9-11 October 2006, UNEP RRCAP, AIT, Bangkok, Thailand

C O N T E N T S

LIST OF ACRONYMS

AIT	Asian Institute of Technology
APINA	Air Pollution Information Network for Africa
AQM	Air Quality Management
CPCB	Central Pollution Control Board
CORNET	Corrosion Network program
IIAS	Integrated Information and Assessment System
IVL	IVL Swedish Environmental Research Institute
KiMab	Corrosion and Metals Research Institute
MISU	Department of Meteorology - Stockholm University
MTECH	National Metal and materials Technology Center
Pak- EPA	Pakistan Environmental Protection Agency
RAPIDC	Regional Air Pollution in Developing Countries
SEI	Stockholm Environment Institute
Sida	Swedish International Development Cooperation Agency
UNECE	United Nations Economic Commission for Europe
ICP	International Cooperative Programme
CLRTAP	Convention on Long-Range Transboundary Air Pollution
UNEP RRC.AP	United Nations Environment Programme Regional Resource Center for Asia and the Pacific

Training Workshop on Evaluation of Corrosion Attack on Materials

9-11 October 2006
UNEP RRCAP, AIT, Bangkok, Thailand

1. Introduction

Malé Declaration program (i.e., Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia) and CORNET (Corrosion Network program) jointly organized a training workshop on evaluation of corrosion attack on material during 9-10 October 2006 at UNEP Regional Resource Centre for Asia and the Pacific (RRCAP), Asian Institute of Technology (AIT), Bangkok, Thailand. On the 11th October, the workshop was followed by a meeting of CORNET (Corrosion Network), which is a joint network of Malé Declaration and Air Pollution Information Network for Africa (APINA). Both Malé Declaration and APINA are parts of RAPIDC (Regional Air Pollution in Developing Countries) program.

There were 30 participants in the workshop: 9 from Malé Declaration countries (Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, Sri Lanka), 9 from CORNET countries (Hong Kong, Vietnam, China, Malaysia, Thailand), 5 from APINA network, African countries (Mozambique, Tanjania, Zimbawe, Zambia) and others from collaborating institutions; Corrosion and Metals Research Institute (KiMab) and UNEP RRC.AP. The list of participants is enclosed (annex 1). The workshop was aimed at capacity building in 8 Malé Declaration countries and other participating countries for studying the evaluation of corrosion of acid deposition on various materials and consequently enabling them to design science-based policy options to mitigate air pollution and its adverse effects on materials. Thus, the workshop was designed to provide the basic theoretical concepts and a technical hands-on training to the participants on simulation as well as evaluation of corrosion attacks of acid deposition on a wide range of materials, ranging from zinc and carbon steel to the stones that resemble the stones used in making sculptures and monuments.

2. Opening Session

The session started with a brief introduction of the participants.

Mr. Surendra Shrestha, UNEP Regional Director and Representative for Asia and the Pacific, was present at the opening session. The Regional Director welcomed all participants, and appreciated involvement of participating countries and technical support and advice from SEI (Stockholm Environment Institute) and KiMab in the programme. In his opening remark, Mr. Shrestha expressed his pleasure on a combined participation from Malé Declaration, CORNET network and expertise from Europe. He reminded the participants about the time required (~2 decades) to understand the transboundary transport of air pollutants, its science, impacts and policy formulation in Europe. He emphasized that we should learn from European experience, but we cannot go through the

same lengthy time period. He also pointed out the need for intensive study on health effects of air pollution, including the aging problem, if there is any linkage. He advised participants for active participation so as to make use to the fullest extent of the lectures, training exercises, sharing knowledge and experiences among participants, and enhance their capability. He looked forward to a fruitful learning from the workshop.

Dr. JohanTidbald (KiMab) talked briefly about the long history of transboundary pollution in Europe and corrosion problems, including destruction of some precious monuments and sculptures. He pointed out the differences in climate and weather in Asia and Africa from Europe and their implications on corrosion of materials, and the need to have the atmospheric corrosion studies in Asia and Africa in order to fully comprehend the role of various controlling factors in corrosion, while utilizing the relevant knowledge from Europe. He thanked the host (UNEP RRC.AP) of the workshop, the funding agency (Sida), SEI and all participants.

Mr. Mylvakanam Iyngararasan (UNEP) mentioned that it was the first workshop for corrosion evaluation within Malé Declaration, and mentioned that the workshop had been participated by other networks such as CORNET and APINA. He introduced briefly the Malé Declaration programme, its phases and components, ongoing Phase III in articular, national and regional networks, recent regional meetings, development of various manuals, and plan for the coming days that included impact assessment of transboundary air pollution and case studies for rapid urban assessment, crop impact assessment and corrosion attack studies.

3. Training Programme: Evaluation of Corrosion Attack on Materials

The training programme covered a wide range of aspects of corrosion study, such as introduction of theoretical concepts of corrosion, atmospheric corrosion, and simulation of corrosion attack, i.e., sample preparation, exposure and evaluation of corrosion attack on materials. The demonstration of how to conduct corrosion study was the main focus of the workshop.

Dr. Johan Tidbald (KiMab) highlighted the objectives of the workshop in the context of RAPIDC, and underlined that the capacity building was the aim of the training workshop, and presented the schedule for the 3-day workshop including the first meeting of CORNET on 11 October. He presented an overview of the aims, progress and future plan of RAPIDC programme. He mentioned about the networking of various policy dialogues and initiatives in South Asia, Southern Africa and Latin America, and the various activities that have been carried out under the framework of RAPIDC programme, as well as CORNET and its history. While presenting the various components of IIAS (integrated information and assessment system), Dr. Tidbald emphasized the need of science-based knowledge for assessing the effects of impacts of air pollution at different scales (indoor, urban, regional etc.), and air pollution management in Asia. He presented some future plan of RAPIDC programme such as air pollution and children health study in Bangladesh, and rapid urban assessment in Kathmandu, Nepal. Dr. Tidbald showed some examples of atmospheric corrosion studies of various materials (steel, lime stones) in Asia and Africa. Finally, he highlighted the disproportionate effects on poor people, women and children. He also introduced the objectives of the workshop for new CORNET members, i.e., to provide review of corrosion, to provide knowledge through

theoretical training accompanied by hands-on training/demonstrations, and overview on how to evaluate samples for corrosion attacks.

Dr. Vladimir Kucera (KiMab) introduced the Corrosion and Metals Research Institute (KiMab), the research activities at KiMab and the services it provides. He presented an overview the practical aspects of atmospheric corrosion. He started with a brief overview of the history of air pollution and its effects on materials in Europe and North America. He provided examples of systematic exposure experiments in the laboratory and in the field, for instant, the exposure experiments in Sweden and Czech Republic, in order to assess the corrosion attacks of pollutants. He mentioned about the corrosion effects of various pollutants such as sulphur dioxide, oxides of nitrogen, ozone, chloride, and the effects of multi-pollutants and the meteorological parameters. Remarkably higher corrosively of nitric acid was illustrated, so as the higher corrosion rates in the wet tropical regions. He thus, stressed on the uniqueness of the tropical regions, and cautioned that the results from Europe may not be transferable to other part of the world. He presented the dose-response functions, i.e., the pollution level vs. the corrosion rate and explained about the acceptable level, tolerance, target level, and limit values (legal standards) of corrosion. Mr. Kucera highlighted the importance of producing corrosion maps for public and policy makers, and the benefits of reducing air pollution.

Dr. Kucera introduced the standardization in atmospheric corrosion, mainly ISO standards, terminologies used in corrosion standards, standards concerning atmospheric corrosion, classification of corrosivity, corrosion testing methods in the laboratory and field. Dr. Tidbald continued with the practical applications of various ISO standards, in particular field exposure. He presented the standard requirements for the field test, including site selection, specimen, types, specimen preparation, handling, exposure (both in lab and atmospheric exposure), sheltered and unsheltered exposure, test duration, specimen dismounting and storage, and data recording during the corrosion study. He also mentioned that the corrosion of materials may impact the environment, for example, wash out and runoff of corrosion products into water bodies.

Pointing out the fact that various monuments and sculptures are made up of stones, Dr. Kucera presented various mechanisms of corrosion of stone materials and evaluation of stone degradation using limestone as indicator. He provided the information on Portland limestone and its usefulness as reference material for the study of corrosion attacks on stones.

In the afternoon of 9 October, UNEP RRC.AP organized a field visit to National Metal and materials Technology Center (MTECH), which is located inside the Thammasat University in the neighborhood of Asian Institute of Technology. The detail on field visit will be discussed in next section.

October 10 was devoted mainly on the demonstration of preparation of materials for corrosion study and evaluation of corrosion attack on materials.

Mr. Farid Samie (KiMab) demonstrated procedures to prepare materials for exposure including specimen type, dimension, pre-treatment, marking, weighing, packing, handling, design of racks for placing specimen, sample exposure, sample dismounting,

transport and storage. The participants were highly interested in the demonstration of various steps of the protocol, and they had a number of questions.

While Mr. Samie demonstrated the steps of the protocol, Dr. Tidbald provided an overview of the methods for evaluation of corrosion of exposed specimen, i.e., the basic ways to quantitatively assess the corrosion attack, and Dr. Kucera provided details on how to evaluate the corrosion attacks on metals and alloys referring to various ISO standards, such as removal of corrosion products from corrosion test materials, cutting and analysis of spread from the cut of painted samples, and standard for evaluation of degradation. Dr. Kucera also presented with examples the general deterioration forms under sheltered conditions. He presented the different corrosion testing methods in the laboratory or simulation of atmospheric conditions and corrosion attacks on various materials, and suitability of corrosion test methods for different materials in different field applications. Two of such methods were Salt Spray Test and Immersion Technique.

Dr. Tidbald provided fundamental aspects of the role of atmospheric conditions on corrosion attack, classification of corrosivity of atmosphere, i.e., effects of various gaseous pollutants, particulate matter, precipitation, temperature, and the statistical analysis of corrosion attack (dose-response function).

Mr. Samie summarized the important practical points for sample preparation, exposure, handling, dismounting, storage and evaluation.

4. Field Visit

The participants were taken to the National Metal and Materials Technology Center (MTECH), National Science and Technology Development Agency. It is located inside Thammasat Univeisity near AIT Campus. MTECH has a facility with state-of-the-art equipments for corrosion testing and evaluation. *Dr. Siriluck Nivitchanyong,* Associate Professor and Assistant Director for Research and Development and her colleagues presented their research activities on corrosion testing, and provided a guided tour of their corrosion testing facilities and material injection and molding facility. This was a good opportunity for those participants who are relatively new in the corrosion study, as well as those experienced, to get acquainted with a number of techniques and instrumentation used in the corrosion study. The participants keenly interacted with the experts at MTECH.

5. First Meeting of CORNET

The first meeting of Corrosion Network (CORNET) was held at UNEP RRC.AP on 11 October 2006. Participants from Malé Declaration, CORNET and APINA participated the meeting along with the experts from KiMab and UNEP RRC.AP participants.

Dr. Tidbald presented the draft agenda for the meeting and the participants approved it. The agenda is attached. The meeting continued with the item-wise presentation, discussion and agreements.

Dr. Tidbald shared the experience from the Task Force Meeting of the UNECE ICP (international cooperative programme) of the CLRTAP (Convention on Long-Range

Transboundary Air Pollution). In this regard he presented briefly CLRTAP, its origin and organizational structure, ICP material meetings.

The meeting engaged into deeper discussion on the results and analyses of 4-year RAPIDC exposure experiments for corrosion studies, data reporting (data completeness including environmental data, and missing data). There were presentations from each site followed by the discussion on each individual presentation regarding the data completeness and the actions needed to collect the required data with a good quality. The participants from India, Thailand, Vietnam, China, Hong Kong, Malaysia, Zimbabwe and Zambia presented their results. The presenters were reminded of any missing data or data incompleteness, and some of them agreed to send the data, which was not sent earlier, to Farid. The preliminary results from each presentation, which included exposure of steel, zinc, painted steel, and lime stones (2-year exposure) were discussed in detail to the extent possible to facilitate the better interpretation of the results. The possibility of continued exposure was discussed. It depends on fund availability (external or internal) and interest of the individual groups. The acute financial issue of Southern African countries was raised, and agreed to discuss this in APINA meeting.

Likewise, the program for new exposure sites in Kathmandu, Bangladesh and Pakistan was discussed. It was advised to the participating countries that the selection of a particular country for a given study depends strongly on the interest shown by that particular country, and to less extent, a balanced distribution of the case studies among the participating countries. While designing the corrosion study, the local interest should be taken into consideration. For example, it was suggested that the stone specimens that resemble various statues and sculptures in Kathmandu be chosen for the exposure study in Kathmandu.

The meeting discussed the data management and rules for publication. It has been agreed that each contributor will be given an appropriate opportunity for co-authorship, or be duly acknowledged. It has been agreed that a prior approval from data owner is needed before making the data public or disseminate to other parties. The national agencies should be referred to as data source, the agreement includes.

It was also agreed that the presentation by each country in the next meeting should have a uniform format. Minute of the first CORNET meeting is mentioned in annex 3.

6. Evaluation and Comments from Participants

All participants were provided with the questionnaire for the evaluation of the training workshop so that they can provide their comments and feedbacks on the contents, methodology used in the workshop as well as logistics provided to them. The summary of the evaluation is presented in annex 4. Overall, 38% of the participants rated the training workshop as “Excellent”, 62% rated it as “good”, and none for “Average” or “Unsatisfactory”.

7. Work Plan until Next Workshop

The participants will explore the possibility of holding next workshop next year. No date has been fixed.

Annex 1: List of Participants

<table>
<tr><th colspan="2">South and South East Asia</th></tr>
<tr><td>Bangladesh

1. Mr. Md. Mustafizur Rahman Akhand,
Senior Chemist,
Dhaka Divisional Office,
Department of Environment
Paribesh Bhaban, E-16, Agargaon,
Sher-E-Bangla Nagar,
Dhaka-1207, Bangladesh
Tel: 880-2-9110603,
Fax: 880-2-9118682,
E-mail: akhand@doe-bd.org</td><td>Bhutan

2. Mr. Nedup Tshering
Program Coordinator,
(Malé Declaration in Bhutan)
National Environment Commission (NEC)
Royal Government of Bhutan,
P.O. Box 466, Thimphu, Bhutan
Tel (O): 975-2-323384/ 325856, Fax (O): 975-2-323385
Email: neduptshering@druknet.bt</td></tr>
<tr><td>China

3. Dr. Zhao Dawei
Chongqing Institute of Environmental Science and Monitoring
37#, Jia Ling VL G-1, Jiang Bei District
Chongqing, Post Code: 400020
China
Email: zhaodawei@cta.cq.cn</td><td></td></tr>
<tr><td>Hong Kong

4. Mr. Benny So
Environmental Protection Officer
Environmental Protection Department,
Hong Kong
47/F, Revenue Tower, 5 Gloucester Road,
Wanchai, Hong Kong
Email: bennyso@epd.gov.hk</td><td>

5. Mr. Chiu Kei Yuen
Senior Environmental Protection Officer
Environmental Protection Department, Hong Kong
47/F, Revenue Tower, 5 Gloucester Road,
Wanchai, Hong Kong
Email: ckyuen@epd.gov.hk</td></tr>
<tr><td>India

6. Dr. D. Saha,
Scientist and In-charge
Central Pollution Control Board,
Project office, 4-Dholpur House (near Chhipitola Xing), M. G. Road,
Agra-282 001, India
Tel.:91-562-2421548 Fax: 91-562-2421568
cell No: 091-94-122 60942
Email : cpcbagra@rediffmail.com and cc_lab@dataone.in</td><td>

7. Dr. S.N. Das
Scientist F & Deputy Director
Regional Research Laboratory (CSIR)
Govt. of India
Bhubaneswar 751013
India
Tel: 91-674-2581636 (540 extn.)
Email: sn_das@yahoo.com</td></tr>
</table>

Iran 8. Mr. Mashaallah Tohidi Department Of the Environment, Environment Research Center, Pardisan Nature Park. Shahid Hemat Highway,Tehran-Iran Tel:(+9821)88267996 Email: pooyatohid@yahoo.com	**Malaysia** 9. Ms. Rosita Galang Satellite Division, Malaysian Meteorological Department, Jalan Sultan, 46667 Petaling Jaya, Selangor D.E. Tel: 603 - 7967 8087 Fax: 603 - 7955 0964 email: rosita@kjc.gov.my
Maldives 10. Mr. Abdul Muhsin Ramiz Deputy Director, Department of Meteorology, Orchid Building, Orchid Magu, Malé, Maldives Tel.: 960 3326341 Mobile: 960 7783243 Fax: 960 3320021 Email: abdul_muhusin@meteorology.gov.mv; admin@meteorology.gov.mv	**Nepal** 11. Ms. Bidya Banmali Pradhan Environment Officer, MENRIS, International Centre for Integrated Mountain Development (ICIMOD), P.O. Box 3226, Kathmandu, Nepal Tel (O): 977-1-5525313 ext. 566; (R): 977-1-4253044, Fax: 977-1-5524509/5536747 Email: bbanmali@icimod.org
Pakistan 12. Ms. Nadia Aftab, Assistant Director Pakistan Environmental Protection Agency (Pak-EPA) House #311, Main Margala road, Sector F-11/3, Islamabad 44000, Pakistan Fax: 92-51-9267622 Email: nadiaabassi@gmail.com, pakepa@isb.compol.com	**Sri Lanka** 13. Ms. R.A.Warnika Ranawaka Arachchi Senior Environmental Officer Central Environmental Authority 104, Robert Gunawardana Mawatha Battaramulla, Sri Lanka Tel: (O) 94-11-2278872 ext. 239 (R) 94-777-287264 Email: vernika@cea.lk
Thailand 14. Ms. Rachaneepen Pensit Deputy Director of Material Properties Development laboratory/ Material Property Analysis & Development Centre Thailand Institute of Scientific and Technological Research Bangkok Tel: 662-5779264-79 Fax: 662 577 4160-1 Email: mpad@tistr.or.th 15. Mrs. Rujeeporn Nakkuntod Thailand Institute of Scientific and Technological Research Bangkok	 16. Mr. Sorrasak Suphonlai Thailand Institute of Scientific and Technological Research Bangkok

Vietnam 17. Dr. Le Thi Hong Lien Atmospheric Corrosion Group, Institute of Materials Science, Vietnamese Academy of Science and Technnology. 18 Hoang Quoc Viet, Cau Giay, Hanoi E-mail: honglien@ims.vast.ac.vn	 18. Ms. Hoang Lam Hong Engineer of Chemistry Institute of Materials Science, Vietnamese Academy of Science and Technnology. 18 Hoang Quoc Viet, Cau Giay, Hanoi Email: honghl@ims.vast.ac.vn
Southern Africa	
Zimbabwe 19. Mainford Toga Department of Metallurgical Engineering Univeristy of Zimbabwe Box MP 167 Mt Pleasant Harare, Zimbabwe Email: mainford@eng.uz.ac.zw Mobile: 26311 880841	**Mozambique** 20. Mr. Manuel Lazaro Chissico Universidade Eduardo Mondlane Faculdade de Ciencias, Departamento de Física Av Julius Nyerere 3453 Campus Universitario Principal Maputo-Mozambique Tel: +258 21 497 174 Mobile: 258824993290 Email: malaba@uem.mz
Zambia 21. Mr. Chozi Lungu School of Mines University of Zambia Box 32379 Lusaka, Zambia Tel/Fax: +2601294086 Mobile: +26096954007 Email: metalmins@yahoo.com	 22. Mr. Chilekwa Kampeshi Senior Environmental Co-ordinator, Mopani Copper Mines Plc Central street, Nkana West Box 22000, Kitwe Zambia Tel.: + 260 2 247089 Fax: + 260 2 247445 Mobile: + 260 95 819725 Email: chilekwa.kampeshi@mopani.com.zm
Tanzania 23. Mr. Albert Mmari Physics Department University of Dar es Salaam P.O.Box 35063 Dar es Salaam, Tanzania Tel: 255222668452 Mobile: 255754281618 Email : Albert_Mmari@yahoo.com	

Resource Person 24. Farid Samie Corrosion & Metals Research Institute Drottning Kristinas väg 48 114 28 Stockholm, Sweden Phone: +46 (0)8 674 17 85 Mob.: +46 (0)70 407 67 88 Fax: +46 (0)8 674 17 80 Email: Farid.Samie@kimab.com	 25. Dr. Vladimir Kucera Corrosion & Metals Research Institute Drottning Kristinas väg 48 SE-114 28 Stockholm Sweden Tel: +46 8 440 48 00, Fax: +46 8 440 45 35 Email: vladimir.kucera@kimab.com
26. Dr. Johan Tidblad RAPIDC/Corrosion Project leader Email: johan.tidblad@kimab.com	
UNEP RRC.AP 27. Mylvakanam Iyngararasan Senior Programme Officer UNEP RRC.AP, Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Fax: 662 516 2125, Tel: 662 524 6239 E Mail: iyngara@rrcap.unep.org	 28. Naw Wah Wah Htoo Programme Officer, UNEP RRC.AP, Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Fax: 662 516 2125, Tel: 662 524 6234 Email: wahwah@rrcap.unep.org
29. Dr. Maheswar Rupakheti Senior Programme Officer, UNEP RRC.AP, Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Fax: 662 516 2125, Tel: 662 524 6163 Email: maheswar@rrcap.unep.org	30. Jacob Kurian Programme Officer, UNEP RRC.AP, Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Fax: 662 516 2125 Tel: 662 524 5352 Email: Jacob@rrcap.unep.org

Annex 4: Summary of the evaluation of workshop

Question	Not at all (%)	A little (%)	Somewhat (%)	Mostly (%)	Completely (%)
Overall objectives and content 1. Were the objectives clear and precise 2. Were the objectives attained? 3. Was the content linked to the objectives? 4. Was the content well structured? 5. Was the content presented clearly?			15% 15% 8% 8% 23%	46% 77% 54% 46% 46%	38% 8% 38% 46% 31%
Methodology 6. Was the methodology used appropriate for the training program and you as a professional? 7. Did the methodology help you to share your own knowledge and experience?			8% 8%	38% 54%	46% 32%
Logistics 8. Was the meeting venue adequate? 9. Was the timing of the agenda comfortable? 10. Was the length of the sessions appropriate?		8%	15%	46% 54% 38%	46% 31% 38%
	Excellent (%)	Good (%)	Average (%)	Unsatisfactory Poor (%)	
11. Overall, how would you rate the training? Please circle one.	38%	62%			