UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 1, 2015

Dr. Seungjin Kim
Pennsylvania State University - University Park
Office of Sponsor Programs
110 Technology Center Building,
University Park, PA 16802

VIA Electronic Mail
sxk86@psu.edu

SUBJECT: GRANT NO: NRC-HQ-60-15-G-0003

Dear Dr. Seungjin Kim:

Pursuant to the authority contained in the Federal Grant and Cooperative Grantee Act of 1977 and the Atomic Energy Act of 1954, the Nuclear Regulatory Commission (NRC) hereby awards to the Pennsylvania State University - University Park (hereinafter referred to as the "Grantee" or "Recipient"), the sum of $494,153.00 to provide support to the "Experiments on Scalability of Horizontal Two-phase Flow in Small and Large Diameter Pipes" as described in attachment B entitled "Program Description."

This award is effective as of the date of this letter and shall apply to expenditures made by the Grantee furtherance of program objectives during the period beginning with the effective date of May 1, 2015 and ending April 30, 2018.

This award is made to the Recipient on condition that the funds will be administered in accordance with the terms and conditions as set forth in Attachment A (the Schedule); Attachment B (the Program Description); and Attachment C (the Standard Provisions); all of which have been agreed to by your organization.

Please ensure individuals selected as beneficiaries of support under this grant meet the legal requirements consistent with recent Supreme Court Decisions including *Fisher, Gratz, and Grutter.*

Please sign the enclosed grant to acknowledge your receipt of the award, and return as a pdf file to Ms. Sunshine Wilson by email at Sunshine.Wilson@nrc.gov.

Sincerely yours,
M'Lita Carr
M'Lita Carr
Grants Officer
Resources and Grants Team
Acquisition Management Division

Attachments:
Attachment A – Schedule
Attachment B – Program Description
Attachment C – Standard Terms and Conditions

SUNSI REVIEW COMPLETE

TEMPLATE - ADM001

ADM002

Grant and Cooperative Agreement

CHOOSE ONE:
- [ ] COOPERATIVE AGREEMENT
- [X] GRANT

CHOOSE ONE: [ ] EDUCATION [ ] FACILITIES [X] RESEARCH [ ] SDCR [ ] TRAINING

1. GRANT/COOPERATIVE AGREEMENT NUMBER	2. SUPPLEMENT NUMBER	3. EFFECTIVE DATE	4. COMPLETION DATE
NRC-HQ-60-15-G-0003		05/01/2015	

5. ISSUED TO
NAME/ADDRESS OF RECIPIENT (No., Street, City/County, State, Zip)
PENNSYLVANIA STATE UNIVERSITY, THE
Attn: Mrs. Allison Eisenhower
110 TECHNOLOGY CENTER
UNIVERSITY PARK PA 168027000

6. ISSUED BY U.S. NRC - HQ
Mailing Address: Acquisition Management Division
Mail Stop: 3WFN-05-C64MP
Washington DC 20555-0001

7. TAXPAYER IDENTIFICATION NO. (TIN)
24-6000376

8. COMMERCIAL & GOVERNMENT ENTITY (CAGE) NO.

9. PRINCIPAL INVESTIGATOR/ORGANIZATION'S PROJECT OR PROGRAM MGR. (*Name & Phone*)
Dr. Seungjin Kim
Email: sxk86@psu.edu; Phone: 814-867-1783

10. RESEARCH, PROJECT OR PROGRAM TITLE
Experiments on Scalability of Horizontal Two-phase Flow in Small and Large Diameter Pipes

11. PURPOSE
See Schedule

12. PERIOD OF PERFORMANCE (*Approximately*)
05/01/2015 through 04/30/2018

13A.	AWARD HISTORY	13B.	FUNDING HISTORY
PREVIOUS	$0.00	PREVIOUS	$0.00
THIS ACTION	$494,153.00	THIS ACTION	$494,153.00
CASH SHARE	$0.00	**TOTAL**	$494,153.00
NON-CASH SHARE	$0.00		
RECIPIENT SHARE	$0.00		
TOTAL	$494,153.00		

14. ACCOUNTING AND APPROPRIATION DATA
2015-X0200-FEEBASED-60-60D003-11-6-213-1045-4110

PURCHASE REQUEST NO.	JOB ORDER NO.	AMOUNT	STATUS
RES-15-0136			

15. POINTS OF CONTACT

	NAME	MAIL STOP	TELEPHONE	E-MAIL ADDRESS
TECHNICAL OFFICER	SARAH B. SHAFFER		301-251-7942	SARAH.SHAFFER@NRC.GOV
NEGOTIATOR				
ADMINISTRATOR	M'LITA R. CARR		(301) 415-6869	MLITA.CARR@NRC.gov
PAYMENTS				

16. THIS AWARD IS MADE UNDER THE AUTHORITY OF:
Pursuant to Section 31b and 141b of the Atomic Energy Act of 1954, as amended

17. APPLICABLE STATEMENT(S), IF CHECKED:
- [ ] NO CHANGE IS MADE TO EXISTING PROVISIONS
- [ ] FDP TERMS AND CONDITIONS AND THE AGENCY-SPECIFIC REQUIREMENTS APPLY TO THIS GRANT

18. APPLICABLE ENCLOSURE(S), IF CHECKED:
- [ ] PROVISIONS
- [ ] SPECIAL CONDITIONS
- [ ] REQUIRED PUBLICATIONS AND REPORTS

UNITED STATES OF AMERICA		COOPERATIVE AGREEMENT RECIPIENT	
CONTRACTING/GRANT OFFICER	DATE	AUTHORIZED REPRESENTATIVE	DATE
M'LITA R. CARR	04/16/2015		

Grant and Cooperative Agreement

ITEM NO. (A)	ITEM OR SERVICE (Include Specifications and Special Instructions) (B)	QUANTITY (C)	UNIT (D)	ESTIMATED COST	
				UNIT PRICE (E)	AMOUNT (F)
	CFDA Number: 77.009 Payment will be made through the Automated Standard Application for Payment (ASAP.gov) unless the recipient has failed to comply with the program objectives, award conditions, Federal reporting requirements or other conditions specified in 2 CFR 215 (OMB Circular A110). Payment: ASAP GRANT FUNDS REIMBURSEMENT SYS US TREASURY Period of Performance: 05/01/2015 to 04/30/2018 NRC-HQ-60-14-FOA-0001				

ATTACHMENT A - SCHEDULE

A.1 PURPOSE OF GRANT

The purpose of this grant is to provide support to the "Experiments on Scalability of Horizontal Two-phase Flow in Small and Large Diameter Pipes" as described in Attachment B entitled "Program Description."

A.2 PERIOD OF GRANT

1. The effective date of this Grant is May 1, 2015. The estimated completion date of this Grant is April 30, 2018.

2. Funds obligated hereunder are available for program expenditures for the estimated period: May 1, 2015 – April 30, 2018.

A. GENERAL

1. Total Estimated NRC Amount:	$494,153.00
2. Total Obligated Amount:	$494,153.00
3. Cost-Sharing Amount:	$0.00
4. Activity Title:	Experiments on Scalability of Horizontal Two-phase Flow in Small and Large Diameter Pipes
5. NRC Project Officer:	Sarah Shaffer
6. Technical Analyst:	Kirk Tien
7. DUNS No.:	003403953

A.3 BUDGET

Revisions to the budget shall be made in accordance with Revision of Grant Budget in accordance with 2 CFR 215.25.

	Year 1	Year 2	Year 3
Personnel	$ 18,605.00	$ 19,069.00	$ 19,546.00
Fringe Benefit	$ 6,697.00	$ 6,864.00	$ 7,036.00
Travel	$ 3,000.00	$ 3,000.00	$ 3,000.00
Equipment	$110,000.00	$ 0.00	$ 0.00
Supplies	$ 3,200.00	$ 18,305.00	$ 8,344.00
Other (Tuition)	$ 50,378.00	$ 51,861.00	$ 53,392.00
Indirect Costs (50.7)	$ 33,120.00	$ 41,515.00	$ 37,221.00
Yearly Total	**$225,000.00**	**$140,614.00**	**$128,539.00**

All travel must be in accordance with the Pennsylvania State University - University Park Travel Regulations or the US Government Travel Policy absent Grantee's travel regulation.

A.4 AMOUNT OF AWARD AND PAYMENT PROCEDURES

1. The total estimated amount of this Award is $494,153.00 for the three year period.

2. NRC hereby obligates the amount of $494,153.00 for program expenditures during the period set forth above and in support of the Budget above. The Grantee will be given written

notice by the Grants Officer when additional funds will be added. NRC is not obligated to reimburse the Grantee for the expenditure of amounts in excess of the total obligated amount.

3. Payment shall be made to the Grantee in accordance with procedures set forth in the Automated Standard Application For Payments (ASAP) Procedures set forth below.

Attachment B – Program Description

RESEARCH OBJECTIVES

The objectives of the present study are:

(1) To perform experiments for horizontal two-phase flow in both a small-diameter and a large-diameter pipes;

(2) To perform experiments in the existing small-diameter (38.10 mm ID) horizontal two-phase flow test facility and establish an extensive database for:

   a. Flow regime map / regime transition criteria; and

   b. Local two-phase flow parameters including void fraction, bubble velocity, interfacial area concentration, bubble Sauter mean diameter, bubble chord length, bubble frequency, and local static pressure, all measured at least three axial locations along the test section in bubbly, plug and slug flow regimes.

(3) To design and construct a large-diameter (101.60 mm ID) horizontal two-phase flow test facility as a counterpart to the 38.10 mm ID test facility.

(4) To perform experiments in the newly established large-diameter (101.60 mm ID) horizontal two-phase flow test facility and establish identical database as listed in Objective (2).

(5) To perform analytical study with the data acquired in both 38.10 mm ID and 101.60 mm ID test facilities with focus on:

   a. Scalability of flow regime transition criteria in horizontal two-phase flow; and

   b. Bubble relative velocity (both $\langle v_r \rangle$ and $\bar{v}_r$), drift-flux velocity $\langle\langle V_{gj} \rangle\rangle$, and two-phase multiplier ϕ_f^2 in horizontal two-phase flow.

(6) To assess the existing closure relations in TRACE based on the database established in the experiments with focus on the following phenomena/parameters:

   a. Scalability of the existing flow regime map and regime transition criteria; and

   b. Feasibility of the existing closure relations for interfacial drag and wall drag forces in horizontal two-phase flow analysis.

(7) To develop necessary closure relations for TRACE accounting for the scalability of pipe sizes that can better predict horizontal two-phase flow phenomena in reactor safety analysis.

SIGNIFICANCE OF THE PROPOSED RESEARCH

There have been concerted efforts in developing extensive high-fidelity database and dynamic models (Ishii et al., 2000; Smith, 2002; Ishii and Kim, 2004; Kim et al., 2004; Ishii et al., 2009, Kim et al., 2010; Yadav et al., 2013). Most of the studies, however, have been directed toward vertical two-phase flow because of its fundamental importance in modeling two-phase flow phenomena. Even though there have been studies to improve database for horizontal two-phase flow through experiments (Iskandrani & Kojasoy, 2001; Lewis, 2002; Yeoh et al., 2012; Bottin et al., 2014), database required for accurate model development is still quite limited. Furthermore, most of the existing database for horizontal two-phase flow has been established in small diameter pipes ranging from approximately 10 mm to 50 mm (particularly for dispersed bubbly flows – see Table 1 in Section 1.1 of present proposal). As such, systematic studies to

investigate scalability of the data and closure relations developed through experiments in small diameter pipes are indispensable for large diameter horizontal two-phase flow analysis. Such scalability study is of particular importance in horizontal two-phase flow, because, unlike vertical two-phase flow, the highly asymmetric distribution of the dispersed phase in horizontal two-phase flow causes fundamental differences in relative motion between the two phases and in flow regime transition characteristics. Assessing the scalability among various pipe sizes is essential, because the ratio between the characteristic bubble length scale (such as the bubble Sauter mean diameter or bubble chord length) and the pipe diameter may govern the severity of the asymmetry in the bubble distribution and the flow regime transition criteria. Therefore, confirmatory study on the scalability of the geometric parameters in horizontal two-phase flow is an indispensable step toward developing accurate closure relations and toward application of the closure relations with confidence.

In view of these, the proposed research performs experiments on horizontal two-phase flow in both a small-diameter pipe and a large-diameter pipe to establish a comprehensive two-phase flow database. The experiment in a small-diameter pipe is performed in a test facility readily available at the AMFL, PSU. The test section of the existing air-water horizontal two-phase flow test facility is made with clear acrylic round pipes of 38.10 mm inner diameter (ID). It provides a total development length of approximately 250 diameters and is capable of generating comprehensive horizontal two-phase flow regimes. As a counterpart of the 38.10 mm ID pipe facility, a "*large-diameter*" air-water horizontal two-phase flow test facility shall be established by constructing a test section from clear acrylic round pipes of 101.60 mm ID as test sections. As such it yields the pipe-diameter to bubble-diameter ratio of more than 30 in dispersed bubbly flow and a total development length of approximately 95 diameters. The 101.60 mm ID pipe facility is designed to be also capable of achieving all conceivable horizontal two-phase flow regimes, including bubbly, plug, slug, stratified, stratified-wavy and intermittent annular flow regimes. Additionally, the large-diameter test section yields more than seven times larger cross-sectional area compared to small-diameter test section. As such, data acquired in two test facilities can be compared in one-to-one manner to assess the scalability of geometric parameters in horizontal two-phase flow.

Thus, upon completion of the proposed study, an extensive high-fidelity two-phase flow database for both the small-diameter pipe (38.10 mm ID) and the large-diameter pipe (101.60 mm ID) horizontal two-phase flow shall be established in a wide range of mixed two-phase flow configurations including bubbly, plug and slug flows. Detailed flow visualization data acquired by the high-speed movie camera for flow regime identification for comprehensive horizontal two-phase flow regimes shall be also established. In view of the existing closure relations in TRACE, assessment results for existing flow regime boundaries & regime transition criteria shall become available. In view of the closure relations for interfacial drag and wall drag forces in TRACE, data for bubble relative velocity (both $\langle v_r \rangle$ and $\bar{v}_r$), drift-flux velocity $\langle\langle V_{gj} \rangle\rangle$, and two-phase multiplier ϕ_f^2 in two-phase frictional pressure loss shall be established. If found necessary, new closure relations accounting for scalability of the pipe sizes that can better represent horizontal two-phase flows shall be developed in the forms to be readily applicable to TRACE.

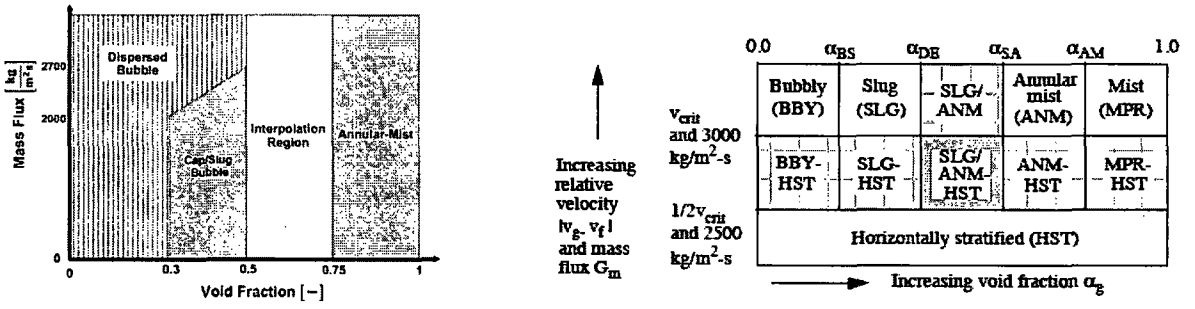
1. THEORETICAL APPROACH

1.1 Flow Regime Map and Regime Transition Criteria for Horizontal Two-phase Flow

In the analysis of two-phase flow phenomena, TRACE relies on flow-regime-map-based closure relations and regime transition criteria in both the 1-D (e.g. PIPE and CHAN) and 3-D (e.g. VESSEL) components. Three major classes of two-phase flow regimes are identified in TRACE, namely; "*pre-CHF flows*", "*post-CHF flows*" and "*stratified flows*" (TRACE V5.0 Theory Manual, 2007). Among these, the "*pre-CHF flows*" class includes the dispersed-gas in continuous-liquid two-phase flow configurations. The pre-CHF flow regime map shown in Fig. 1(a) is employed regardless of the flow orientation; however, a set of criteria is used to determine if the flow is within the "*stratified flows*" class for inclination angles less then 80^0. Here, regime transition criteria based on the total mixture mass flux G with respect to the maximum allowable dispersed bubble fraction, α_{DB}, are given by (TRACE V5.0 Theory Manual, 2007):

$$\begin{aligned} \alpha_{DB} &= 0.3 && for && G \le 2{,}000 \left[kg/m^2 s \right]; \\ \alpha_{DB} &= 0.3 + 0.2\left[\frac{G - 2{,}000}{700} \right] && for && 2{,}000 < G < 2{,}700 \left[kg/m^2 s \right]; \\ \alpha_{DB} &= 0.5 && for && G \ge 2{,}700 \left[kg/m^2 s \right]. \end{aligned} \quad (1)$$

As such, two-phase flows are categorized into four regimes, namely; dispersed bubble, cap/slug bubble, interpolation region, and annular-mist regime. In Eq. (1), a simple mass flux limit of 2,700 kg/m^2-s is used as a transition criterion between the dispersed bubbly flow and the cap/slug flow; this limit is also one of the stratification criteria for horizontal and inclined flow orientations. This mass flux limit was suggested by Choe et al. (1978) and was considered to be applicable to flow channels with any angle of inclination at mass flux above this limit (Spore et al., 2001). Along with the mass flux limit, maximum allowable void fraction serves as the criterion such that the interpolation region is defined as a region between void fractions of 0.5 and 0.75, and the transition to annular flow is given by a criterion of void fraction above 0.75. It is interesting to note that RELAP5 also makes use of similar regime transition criteria based on mass flux limit and maximum allowable void fraction for horizontal two-phase flow, but with slightly different values as shown in Fig. 1 (b) (RELAP5/MOD3.3 Code Manual-Vol.4, 2001).



(a) (b)

Figure 1. Flow regime maps employed by (a) TRACE (TRACE V5.0 Theory Manual, 2007) and (b) RELAP5 (RELAP5/MOD3.3 Code Manual-Vol.4, 2001).

Over the years, it was demonstrated that the mass flux limit of 2,700 kg/m^2-s in Eq. (1) showed relatively good agreement with experiments performed in air/water flows with pipe diameters of 12.7mm, 25.4mm and 50.08 mm. In fact, there have been a number of studies to investigate the flow regime map for horizontal two-phase flow, in view of scalability for different pipe sizes, angle of inclination, pipe geometry and fluid properties as summarized in Table 1 for some notable studies.

Table 1. Summary of notable studies on horizontal two-phase flow

Flow Regimes & Regime Transition for Air-water Horizontal Flow in Round pipe		
Size [mm]	**Author(s)**	**Year**
24; 50; 91; 140	Hoogendoorn	1959
12.7 ~ 165	Mandhane et al.	1974
12.5; 50; 300	Taitel & Dukler	1976
12.7 ~ 94	Choe et al.	1978
4.0 ~ 12.0	Barnea et al.	1983
60	Hervieu & Seleghim	1998
17.8; 50.8	Andreussi et al.	1999
50; 60	Kadri et al.	2009
Flow Regimes & Regime Transition for Air-water Horizontal Flow: Geometry Effects		
Geometry / Size [mm]	**Author(s)**	**Year**
Round (inclined) / 25.4	Barnea	1986
Rectangular / 2x15	Wilmarth & Ishii	1994
Round (Inclined) / 25.4 / Oil-water	Angeli & Hewitt	2000
Round (Inclined) / 19 ~ 102.3	Woldesemayat et al.	2007
Round with 45^0 & 90^0 elbow / 25.4; 50.8	Talley & Kim	2010
Flow Regimes & Regime Transition for Horizontal Flow in Round pipes: Fluid Properties		
Fluids / Pipe Sizes [mm]	**Author(s)**	**Year**
Various combination of fluids[1] / 12; 25.4; 50.8	Weisman et al.	1979
Refrigerant R12; R22 / 10	Hashizume et al.	1987
Refrigerant R134a; R402A; R404A; R502; R123 / 12	Kattan et al.	1998
Oil-water / 25.4 / Round (Inclined)	Angeli & Hewitt	2000
Refrigerant / 7.9; 13.7	Wojtan et al.	2005
Refrigerant / 8; 13.8	Moreno & Thome	2007
Bubble velocity / Phase distribution in Air-water Horizontal Two-phase Flow		
Parameter of Interest	**Pipe Sizes [mm]**	**Author(s)**	**Year**
Pressure drop (bubbly)	25.4; 50.8	Holmes & Russell	1975
Drift-flux (S/S-W/Int./A)	19	França & Lahey	1992
Bubble velocity (bubbly)	50.8	Beattie	1996
Bubble velocity (bubbly)	50.8	Iskandrani & Kojasoy	2001
Bubble velocity (Slug)	50.8	Lewis et al.	2002
phase distribution, velocity (bubbly)	50.8	Yeoh et al.	2012
Drift-flux (comprehensive)	51~149.6	Choi et al.	2012
Bubble distribution, velocity, pressure (bubbly)	38.1	Talley	2012
Bubble distribution, velocity (bubbly)	100	Bottin et al.	2014

As can be seen in the table, however, most of the horizontal two-phase flow studies were performed in a pipe diameter less than 60 mm. Even though some researchers including, Mandhane et al. (1974), Choe et al. (1978), Taitel & Dukler (1976), Woldesemayat et al. (2007) and Choi et al. (2012) compared the regime transition criteria with the data acquired in pipe diameters larger than 100 mm, those data were for stratified and/or stratified-wavy flow conditions, and no data for bubbly flow in such large diameter horizontal two-phase flow is available. More recently, Bottin et al. (2014) reported data acquired in horizontal two-phase flow

[1] air-glycerine, air-water (with differing surface tensions), air-K_2CO_3, freon-freon.

in 25 mm and 100 mm ID pipes. However, this study was focused on investigating bubble velocity and phase distribution, and parametric studies on the scalability of horizontal two-phase flow were not presented. In fact, to date, experimental studies on the scalability of horizontal two-phase flow in different pipe sizes in view of flow regime map and regime transition criteria for transitions between dispersed bubbly and annular flow or between bubbly and plug (or slug) flow are not available. Additionally, the recent work performed at the AMFL, PSU by employing 38.10 mm ID pipes as test sections showed that, unlike the flow regime maps shown in Fig. 1, transition from bubbly flow to slug (or plug) flows may occur even at mixture mass flux of above 4,000 kg/m^2-s, and the transition characteristics depend not only on the void fraction, but also on gas velocity (Talley, 2012). Additionally, local data acquired in the experiments suggested that the area-averaged void fraction alone may not be representative enough to characterize the regime transition phenomena in horizontal bubbly flow, because of the highly asymmetric and skewed void fraction profile in horizontal bubbly flow (unlike in the vertical two-phase flow). Therefore, studies with focus on the scalability of the flow regime map and regime transition criteria for large diameter horizontal two-phase flow is invaluable in view of TRACE application to reactor analysis.

1.2 Drag Closure Relations for Horizontal Two-phase Flow

In the analysis of two-phase flow in TRACE, the primary unknowns include; void fraction ($\square$), pressure (p), phase velocities (v_k), phase densities ($\square_k$) and phase internal energies (e_k). Among these, $\square_k$ and e_k are related to temperature and pressure through equations of state, and v_k is calculated from the equations of motion as a function of the pressure owing to the semi-implicit method used in TRACE. Hence, the independent variables to be calculated in TRACE are $\square p$ and temperature (T_k). In the process, the interfacial drag and wall drag forces in the equations of motion are specified as (TRACE V5.0 Theory Manual, 2007):

Interfacial drag: $f_i = -C_i \bar{v}_r |\bar{v}_r|$ with $\bar{v}_r \equiv \langle\langle v_g \rangle\rangle - \langle\langle v_f \rangle\rangle$ (2)

and

Wall drag: $f_{wk} = -C_{wk} v_k |v_k|$ with $C_{wk} \propto \phi_{2\phi}^2$ (3)

where C_i, $\bar{v}_r$, C_{wk} and $\phi_{2\phi}^2$ are the interfacial drag coefficient, average relative velocity, wall drag coefficient and two-phase multiplier, respectively. Currently in TRACE, the interfacial drag coefficient for the bubbly/slug flow regime is modeled using a drift-flux-based approach that assumes a force balance between the buoyant and steady-state drafg forces such that:

$$C_i = \frac{\langle\alpha\rangle\left(1-\langle\alpha\rangle\right)^3 \Delta\rho g}{\langle\langle V_{gj} \rangle\rangle^2} P_s \text{ with } P_s \equiv \frac{\langle v_r \rangle^2}{\bar{v}_r^2} \quad (4)$$

where P_S is the profile slip factor that accounts for differences between the area-averaged relative velocity, $\langle v_r \rangle$ and $\bar{v}_r$. Hence, the interfacial drag force is dependent on the void fraction and drift-flux velocity $\langle\langle V_{gj} \rangle\rangle$. The wall drag is modeled using a friction factor approach with a two-phase multiplier, and thus it is dependent on the two-phase frictional pressure loss. Consequently, accurate estimations of void fraction $\langle\alpha\rangle$, drift velocity $\langle\langle V_{gj} \rangle\rangle$, area-averaged relative velocity $\langle v_r \rangle$, and frictional pressure loss are directly related to the accuracy of TRACE predictions.

In 1-D components in TRACE, such as PIPE, the drift velocity correlation for the churn-turbulent flow regime (Ishii, 1977) is used for dispersed bubby flows, and the drift velocity correlation developed by Kataoka and Ishii (1987) is used for cap/slug flows (TRACE V5.0 Theory Manual, 2007). These correlations are given respectively as:

$$\langle\langle V_g \rangle\rangle_{CT} = \sqrt{2}\left(\frac{\sigma g \Delta\rho}{\rho_f^2}\right)^{1/4} \quad \text{(Ishii, 1977)} \tag{5}$$

and

$$\langle\langle V_g \rangle\rangle_{KI} = \langle\langle V_{gj}^+ \rangle\rangle\left(\frac{\sigma g \Delta\rho}{\rho_f^2}\right)^{1/4} \text{ with } \langle\langle V_{gj}^+ \rangle\rangle = f\left(D_h^*, g, \rho_g, \rho_f, \sigma, \mu_f\right) \text{ (Kataoka \& Ishii, 1987)} \tag{6}$$

Here, it is important to note that Eq. (6) is furnished to account for the flow channel size with respect to cap bubble size, because in vertical two-phase flow through large diameter pipes, slug bubbles cannot be formed when the bubble size reaches the maximum cap bubble limit. Above this limit, surface instability leads to breakup of large cap bubbles before they can fill the channel. As such, this phenomenon is scaled through the non-dimensional drift velocity $\langle\langle V_{gj}^+ \rangle\rangle$ by employing the non-dimensional hydraulic diameter defined as:

$$D_h^* \equiv \frac{D_h}{\sqrt{\sigma / g\Delta\rho}} \text{ (Kataoka \& Ishii, 1987)} \tag{7}$$

Such consideration may be also needed for horizontal two-phase flow analysis to account for scalability of small-diameter flow to large-diameter flow. In addition to models for $\langle\langle V_g \rangle\rangle$, a model for the area-averaged relative velocity $\langle v_r \rangle$ is required for the profile slip factor, P_s. $\langle v_r \rangle$ is specified according to the model given by Ishii and Mishima (1984) as (TRACE V5.0 Theory Manual, 2007):

$$\langle v_r \rangle = \frac{1 - C_0\langle\alpha\rangle}{1 - \langle\alpha\rangle}\langle\langle v_g \rangle\rangle - C_0\langle\langle v_f \rangle\rangle \text{ with } C_0 = 1.2 - 0.2\sqrt{\rho_g / \rho_f} \tag{8}$$

In employing the closure relations discussed above in TRACE, it is imperative to note that these models require an assumption that the interfacial drag is balanced by the buoyant force. This assumption is central to obtaining the equation for C_i, and the models used for $\langle\langle V_g \rangle\rangle$ and C_0 were developed for vertical two-phase flows. In horizontal two-phase flows, the buoyant force acts perpendicular to the direction of the main flow and as such, may not be directly responsible for the interfacial drag between the two phases in the main flow direction. Therefore, investigation into the mechanisms of relative motion in horizontal two-phase flow is required to develop adequate closure relations for interfacial drag in horizontal flow.

Now considering the closure relation for the wall drag, it is assumed that the wall drag is only applied to the liquid phase since the gas phase does not touch the channel walls in the pre-CHF flow regimes considered in TRACE. As such, C_{wg} is set to zero and only C_{wf} is modeled. The closure relation for liquid-phase wall-drag uses a two-phase friction multiplier approach, similar to the Lockhart-Martinelli model (Lockhart & Martinelli, 1949; Chisolm, 1967). As such, the two-phase friction multiplier used in TRACE is given as (TRACE V5.0 Theory Manual, 2007):

$$\phi_f^2 \propto \frac{1}{(1-\alpha)^{1.75}} \text{ to } \frac{1}{(1-\alpha)^{1.80}} \tag{9}$$

Based on recent experiments performed for horizontal bubbly flow at AMFL, PSU (Talley, 2012), it is evident that additional studies on bubble relative motion in horizontal two-phase flow are indispensable. For example, the measured local bubble velocity, v_g, clearly indicates that the gas phase moves slower than the liquid phase as shown in Fig. 3(a). It is also evident, as

shown in Fig. 3(b), that $\langle\langle V_{gj} \rangle\rangle$ in horizontal bubbly flow becomes negative. While the drift-flux approach is not intended for application toward horizontal two-phase flow, its basic formulation is not limited by flow orientation. In fact, it is interesting to see that the drift velocity correlation developed in Fig. 3(b) based on the acquired data provides quite accurate estimation of void fraction, well within ±10% difference as shown in Fig. 4(a). Additionally, as shown in Fig. 4(b), the pressure analysis performed using the Lockhart-Martinelli's method suggests that the conventional model coefficient value of C=20 may need to be revisited for horizontal two-phase flow, and further validation for two-phase frictional pressure loss model for various flow regimes and for different pipe size in horizontal two-phase flow may be required. Therefore, both experimental and theoretical investigations on the feasibility of existing closure relations for drag in the application toward the large diameter horizontal two-phase flow are indispensable in improving TRACE's capability.

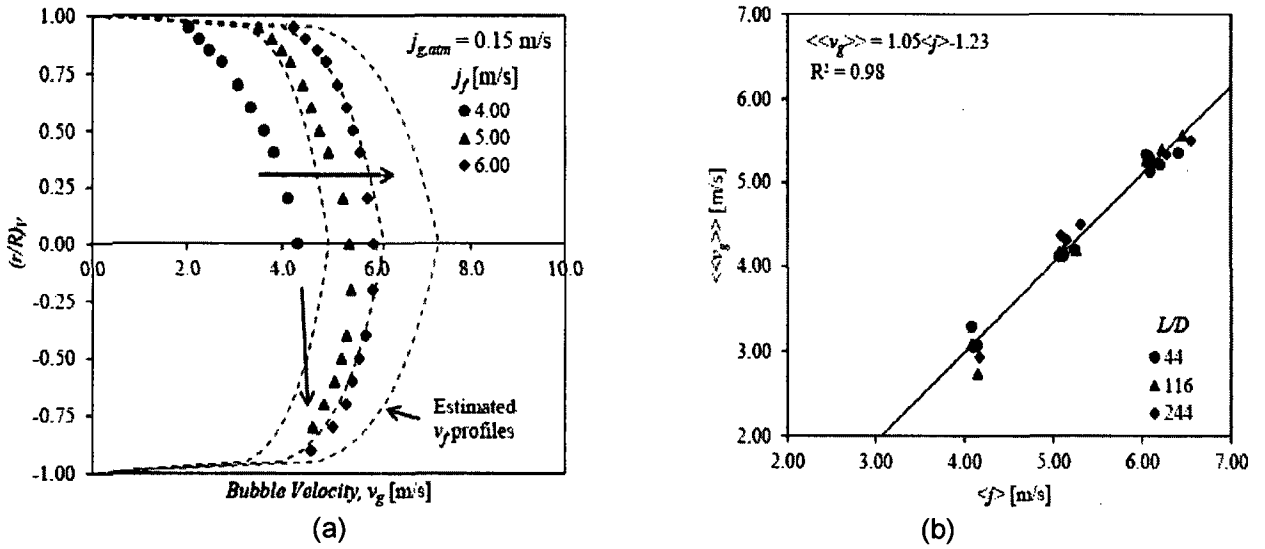


Figure 3. (a) Measured bubble velocity along the vertical diameter of the pipe cross section (shown as points) compared with estimated liquid velocity using the 1/7th law (shown as dashed lines) for three different liquid flow rates at a fixed gas flow rate; (b) Result from the drift-flux analysis of <<v_g>> vs. <j> based on measured data in horizontal bubbly flow, which yielded distribution parameter C_0=1.05 and the drift-velocity <<V_{gj}>>= -1.23 m/s.

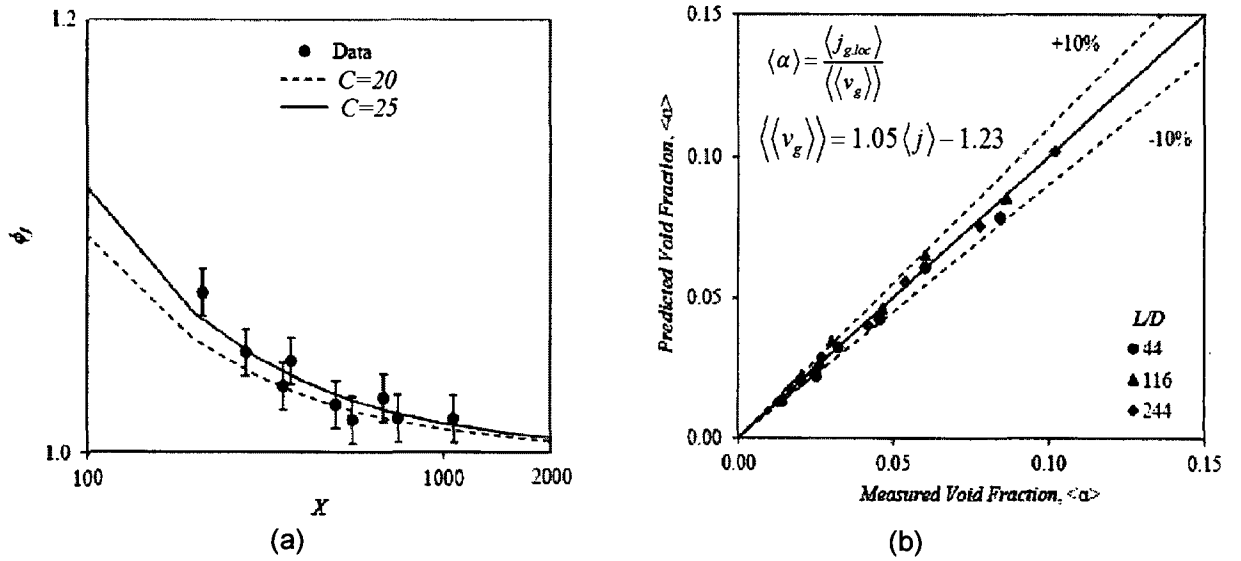


Figure 4. (a) Void fraction predicted using the drift velocity correlation developed in Fig. 3(b), compared with the measured void fraction. Dashed lines denote ±10% variation from perfect match. (b) Two-phase frictional pressure loss predicted by Lockhart-Martinelli method. Dashed line is prediction made by using conventional coefficient value of C=20 and solid line is by C=25.

1.3 Two-phase Flow Phenomena of Interest

Both experimental and analytical investigations on the applicability of the existing closure relations in horizontal two-phase flow as well as the scalability of the models for large diameter pipes are indispensable in improving TRACE capability. In view of these, the database established in the experimental portion of the proposed study shall be utilized to assess existing models. If found necessary, new closure relations that can better represent the horizontal two-phase flow shall be developed, and existing models shall be improved to better predict major horizontal two-phase flow phenomena of interest. As such, the proposed research performs analytical studies on the following closure relations:

Flow regime map and regime transition criteria: Confirmatory study on the available horizontal two-phase flow regime maps is performed based on detailed flow visualization data provided by the proposed experiments. Scalability of regime transition boundaries is investigated. Transition boundaries with particular interest include bubbly to plug transition, bubbly to slug transition, plug to slug, plug to stratified, slug to stratified-wavy, and intermittent regime near annular flow. Existing regime transition criteria available in the literature, including the one implemented in TRACE, are examined for adequacy and scalability.

Bubble distribution and bubble relative velocity: The adequacy of existing closure relations in TRACE for modeling interfacial drag is examined based on the database established through both small- and large-diameter experiments. Bubble relative motion including effects stemming from bubble distribution are studied.

Drift-flux analysis: Drift-flux analysis is important in view of both the closure relation for interfacial drag in TRACE, and its ability to estimate the area-averaged void fraction as discussed with Fig. 4(a). The drift-flux velocity $\langle\langle V_{gj} \rangle\rangle$ determined experimentally through both small- and large-diameter experiments is compared for scalability. The experimentally determined $\langle\langle V_{gj} \rangle\rangle$ shall be also compared with the existing closure relations in TRACE for adequacy. Additionally, feasibility of the $\langle\langle v_g \rangle\rangle$ vs. $\langle j \rangle$ correlation determined experimentally is studied in view of estimating the area-averaged void fraction (as shown in Fig. 4(a)).

Frictional pressure loss: The local static pressure measured by the pressure transducer and other two-phase flow parameters measured at various axial locations in the experiments allow for frictional pressure loss analysis. Analysis using Lockhart-Martinelli method is performed for both the small and large diameter flows. Feasibility of the existing model in TRACE is assessed performed against the correlation deduced from data.

2. EXPERIMENTAL APPROACH

The proposed research performs experiments for horizontal two-phase flow in both a small-diameter pipe and a large-diameter pipe test facilities. While the large-diameter pipe test facility is established during the course the study, the small-diameter test facility is readily available at AMFL, PSU for experiments.

2.1 Perform Experiments in the Existing Small-diameter (38.10 mm ID) Horizontal Two-phase Flow Test Facility

The AMFL, PSU is equipped with an air-water horizontal two-phase flow test facility with test section made with clear acrylic pipes of 38.10 mm in inner diameter and a total development length of approximately 250 diameters. In view of the discussions presented earlier in "*Section 1.3 Analytical Approach*", experiments are performed in the existing test facility to establish database for the following horizontal two-phase flow phenomena:

Flow regime map & regime transition boundaries: An extensive flow visualization study using the high-speed movie camera is performed. Experiments are performed to identify regime transition boundaries. The transition boundaries of particular interest include bubbly to plug,

bubbly to slug, plug to slug, plug to stratified, slug to stratified-wavy, and intermittent regime near annular flow.

Bubble distribution and bubble relative velocity: The local two-phase flow parameters acquired by the four-sensor conductivity probe in the proposed study allows for both detailed three-dimensional information on bubble distribution (see Fig. 6(b) in Secion 3.1 regarding the extensive local measurement capabilities), and accurate estimation of bubble velocity in two forms, namely, $<v_g>$ and $<<v_g>>$. As such, extensive database for both local and area-averaged two-phase flow parameters for bubble velocity is established in various two-phase flow regimes including bubbly, plug and slug flow conditions.

Drift-flux analysis: The two-phase flow data acquired in the experiments can be used to perform drift-flux analysis for each flow regime of interest. Through this analysis, the drift-flux velocities (i.e., $<<V_{gj}>>$) for different flow regimes are obtained. Additionally, simple correlations to estimate the area-averaged void fraction (as discussed in Fig. 4(a)) are obtained.

Frictional pressure loss: The local static pressures are measured by the pressure transducer in bubbly, plug and slug flows at various axial locations along the test section. Along with other two-phase flow parameters measured, database for frictional pressure loss analysis using the Lockhart-Martinelli method is established.

Other two-phase flow parameters: During the course of experiments, an extensive database for other major two-phase flow parameters (not mentioned above) is established for analysis. These include: void fraction, interfacial area concentration, bubble Sauter mean diameter, bubble chord length and bubble frequency.

2.2 Design and Construction of a Large Diameter Horizontal Two-phase Flow Test Facility

The proposed research designs and constructs a large-diameter air-water horizontal two-phase flow test facility. The large-diameter test facility shall be designed to be capable of achieving comprehensive horizontal two-phase flow regimes including bubbly, plug, slug, stratified, stratified-wavy and intermittent annular flows. Round clear acrylic pipes of 101.60 mm ID are employed as test section, yielding the bubble size to pipe diameter ratio of approximately one order of magnitude smaller compared to the small-diameter test section. Additionally, the large-diameter test section yields more than seven times larger flow area compared to small-diameter test section. As such, scalability of characteristic length of the dispersed-phase with respect to the pipe diameter can be readily studied. The proposed test facility yields a total development length of approximately 95 diameters, along which detailed two-phase flow measurements are made at least three axial locations by employing the similar instrumentation ports designed for small-diameter test facility (see Section 3.1 for more discussion on instrumentation ports). Hence, it is capable of local four-sensor conductivity probe measurements, local static pressure measurements and flow visualization using a high-speed digital movie camera.

2.3 Perform Experiments in a Large-diameter (101.60 mm ID) Horizontal Two-phase Flow Test Facility.

The experiments are performed in a large-diameter 101.60 mm ID pipe to investigate scalability of various horizontal two-phase flow phenomena in different pipe sizes. As such, the experimental tasks summarized in Section 2.1 are repeated to establish database for the large-diameter horizontal two-phase flow as a counterpart of the data established in the small-diameter experiments. Hence, this task establishes database for (a) flow regime map & regime transition boundaries, (b) bubble distribution and bubble velocity, (c) drift-flux analysis and (d) frictional pressure loss analysis in the large-diameter (101.60 mm iD) horizontal two-phase flow test facility.

3. EXPERIMENTAL FACILITY AND CAPABILITIES

The AMFL, PSU has technical expertise for the proposed research and is capable of performing both the experimental and analytical studies. AMFL is already equipped with an air-water small-diameter horizontal test facility, instrumentation and other major infrastructures necessary to perform the proposed research. In what follows, experimental capabilities

including the test facilities and measurement techniques available at the AMFL, PSU are summarized.

3.1 Test Facilities

The AMFL, PSU is equipped with an air-water horizontal two-phase flow test facility with test section made with clear acrylic pipes of 38.10 mm in inner diameter and a total development length of approximately 250 diameters. A simplified schematic diagram of the existing test facility is shown in Fig. 5. The test facility is designed to be capable of achieving comprehensive horizontal two-phase flow regimes including bubbly, plug, slug, stratified, stratified-wavy, and intermittent annular flows. Along the test section, there are five axial locations where instrumentation ports can be installed for two-phase flow measurements using the state-of-the-art local four-sensor conductivity probe (Kim et al, 2000). To account for the characteristic asymmetric bubble distribution in horizontal two-phase flow, the instrumentation port, shown in the inset within Fig. 5, is designed to be rotated around the axis of the test section at every 22.5°. As such, the local two-phase flow parameters can be measured throughout the entire flow cross-sectional area as shown by the measurement mesh in Fig. 6(a). Therefore, a CFD-grade, high-fidelity database of comprehensive two-phase flow parameters important for model development can be established. The measured local two-phase flow parameters include: void fraction, bubble velocity, interfacial area concentration, bubble Sauter-mean diameter, bubble chord-length and bubble frequency. In view of flow visualization, the instrumentation port is also designed to serve as a viewport, such that it minimizes the image distortion stemming from pipe curvature by providing a flat surface in the instrumentation port (also shown in the inset of Fig. 5(a)). Examples of measured local data and images captured through the instrumentation port are shown in Figs. 6(b) and 6(c), respectively.

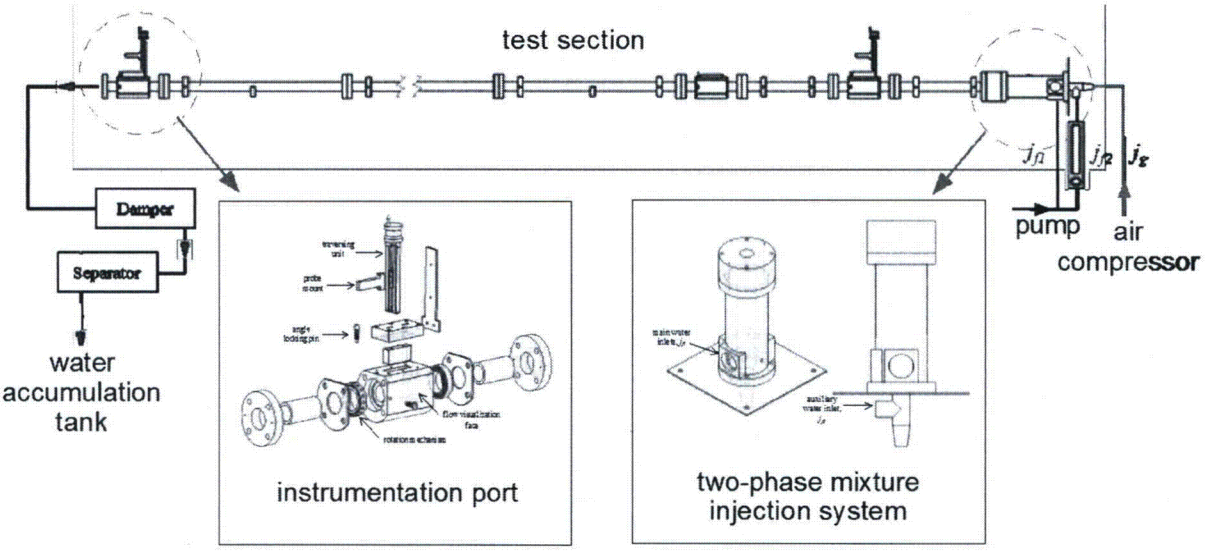


Figure 5. A simplified schematic diagram of the existing air-water horizontal two-phase flow test facility, equipped with a test section made with clear round acrylic pipes of 38.10 mm in inner diameter and the total development length of approximately 250 diameters. Shown in the insets of the figure are local instrumentation port and two-phase mixture injection system.

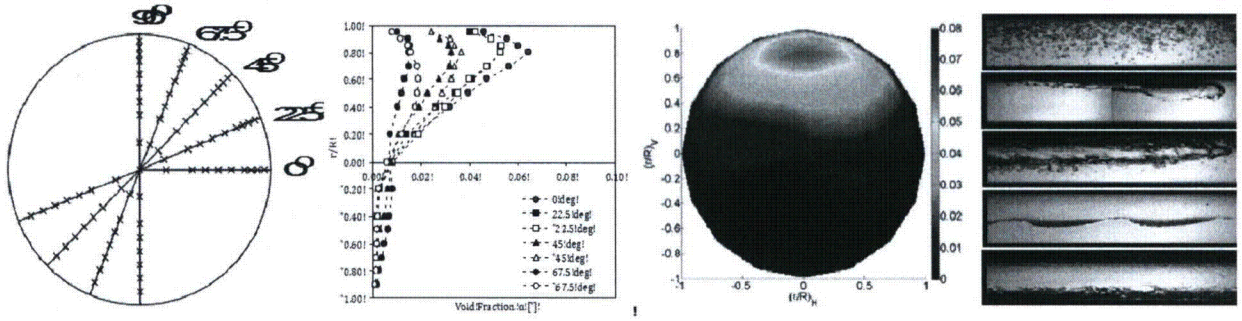


Figure 6. (a) Measurement mesh for local two-phase flow parameters. "x" denotes the location of local measurement. (b) Examples of measured void fraction at L/D=44 in horizontal bubbly flow at flow rates of j_f=6.00 m/s; $j_{g,atm}$=0.15 m/s presented as line and contour plots. (c) Images captured through a viewport in the instrumentation port for bubbly, plug, slug, stratified-wavy and annular intermittent flows (from top to bottom).

3.2 Two-phase Flow Instrumentation

The AMFL, PSU has the unique capability of acquiring local two-phase flow parameters in comprehensive mixed two-phase flow regimes by using the state-of-the-art local four-sensor conductivity probe and signal processing software. Detailed flow visualization is also possible by employing the existing high-speed digital movie camera. The major instrumentation important to the proposed study and its capabilities are summarized as follows:

Local Four-sensor Conductivity Probe: The AMFL, PSU is equipped with the state-of-the-art four-sensor local conductivity probe and its signal processing software. The schematic diagram and the actual image of the probe is shown in Fig. 7. The probe is applicable to a wide range of two-phase flow regimes, including the bubbly, distorted, cap-bubbly, plug, slug and churn-turbulent flow regimes (Kim et al, 2000). The signal-processing program for the probe is capable of categorizing acquired bubble signals into characteristic bubble groups based on the bubble chord-length information. The ease of data acquisition and reliability of the conductivity probe techniques have been validated through extensive benchmark studies (Wu and Ishii, 1999; Kim, 1999; Kim et. al., 2000). The local two-phase flow parameters can be acquired by traversing the probe in the radial direction and the axial evolution of the parameters are acquired by taking the data at several axial locations. The local time-averaged two-phase flow parameters which can be acquired by the probe include: void fraction ($\square$), bubble velocity (v_b), interfacial area concentration (a_i), bubble Sauter mean diameter (D_{sm}), bubble chord length (L_c), and bubble frequency (f_b) for all types of bubbles.

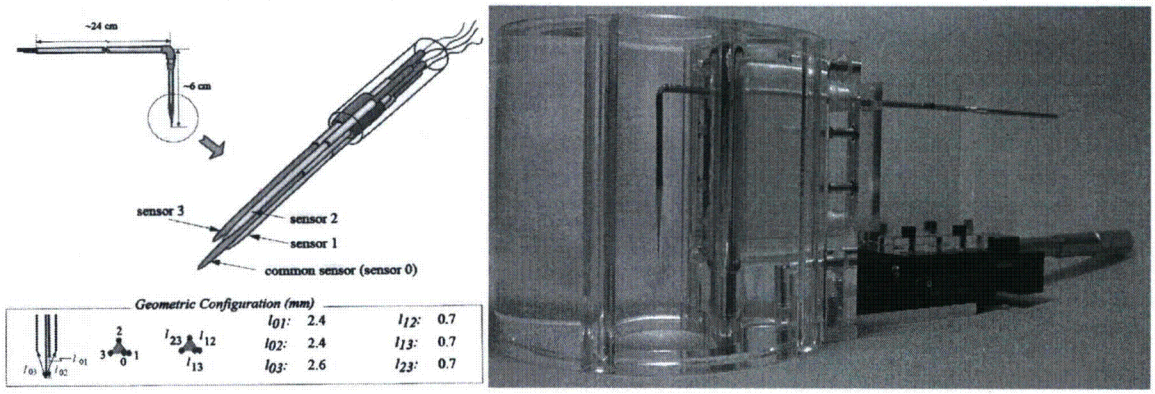


Figure 7. The four-sensor conductivity probe available at AMFL, PSU

High-speed Digital Movie Camera: The AMFL, PSU is equipped with a Photron® Fastcam-Ultima 512 that can capture continuous images at various capture rates ranging from 60 to 32,000 frames per second. Hence, high-quality moving images can be captured in digital format in comprehensive horizontal two-phase flow regimes. Since it requires a minimum liquid flow rate of approximately 4 m/s to achieve bubbly flow in horizontal two-phase flow, the high-speed movie camera is an essential instrument for flow regime identification studies.

Laser Doppler Anemometer (LDA): An integrated LDA system, capable of 1D measurement, is available at AMFL, PSU. The Dantec Dynamics 1D FlowExplorer emits a 35 mW, 660 nm laser beam pair with frequency shifting for positive, zero and negative velocity measurements. The measurement volume diameter and length of this laser system is only 0.1 mm and 1 mm, respectively. The LDA system is an essential instrument to gain understanding on the liquid phase velocity and liquid turbulence. It is capable of measuring the local liquid velocity and turbulence of the continuous phase with maximum measureable and fluctuating velocities of 27 m/s and 0.7 μm/s, respectively.

Other Major Experimental Equipment: Along with the equipment mentioned above, the AMFL of PSU is equipped with other major experimental equipment for the proposed research. These include: a 60 HP and a 10 HP centrifugal pump, 15 HP air compressor with two stage charging tanks, electromagnetic flow meters for single-phase water flow rate, pressure transducers and rotameters for both air and water flow rate measurements.

4. TASK SCHEDULE AND DESCRIPTION

TASK 1: Design and Construction of a Large Diameter (101.60 mm ID) Horizontal Two-phase Flow Test Facility

An air-water horizontal two-phase flow test facility with test section made with round 101.60 mm ID clear acrylic pipes with total development length of approximately 95 diameters. The test facility shall be capable of achieving comprehensive horizontal two-phase flow regimes including bubbly, plug, slug, stratified, stratified-wavy and intermittent annular flows.

TASK 2: Perform Experiments in the Existing 38.10 mm ID Small-diameter Horizontal Two-phase Flow Test Facility.

Task 2.1 : Flow Regime Characterization & Validation
Task 2.2: Experiments in the Bubbly Flow Regime
Task 2.3: Experiments in the Plug Flow Regime
Task 2.4: Experiments in the Slug Flow Regime

Task 2 performs experiments using the existing small-diameter horizontal test facility with focus on: (a) acquiring high-speed movie flow visualization data; (b) establishing flow regime map; (c) establishing an extensive database for comprehensive local time-averaged two-phase flow parameters including void fraction, bubble velocity, interfacial area concentration, bubble Sauter mean diameter, bubble chord length, bubble frequency, local static pressure measured at least three axial locations in bubbly, plug and slug flow regimes.

TASK 3: Perform Experiments in the 101.60 mm ID Large-diameter Horizontal Two-phase Flow Test Facility

Task 3.1 : Flow Regime Characterization & Validation
Task 3.1: Experiments in the Bubbly Flow Regime
Task 3.2 : Experiments in the Plug Flow Regime
Task 3.3: Experiments in the Slug Flow Regime

Task 3 performs experiments using the newly established large-diameter horizontal test facility with focus on: (a) acquiring high-speed movie flow visualization data; (b) establishing flow regime map; (c) establishing an extensive database for comprehensive local time-averaged two-phase flow parameters including void fraction, bubble velocity, interfacial area concentration, bubble Sauter mean diameter, bubble chord length, bubble

frequency, local static pressure measured at least three axial locations in bubbly, plug and slug flow regimes.

TASK 4: Data Analysis, Assessment, and Development of Closure Relations for Horizontal Two-phase Flow

Task 4 performs data analysis for the data acquired in both the small-diameter (38.10 mm ID) and the large-diameter (101.60 mm ID) test facilities and assesses existing closure relations for general horizontal two-phase flows and for horizontal flows with two different pipe sizes. These may include assessment for existing flow regime transition criteria; assessment for existing closure relations for interfacial drag and wall drag forces (more specifically, bubble relative velocity (both $\langle v_r \rangle$ and $\bar{v}_r$), drift-flux velocity $\langle\langle V_{gj} \rangle\rangle$, and two-phase frictional pressure loss via the two-phase multiplier ϕ_f^2). Task 4 also develops closure relations accounting for scalability of pipe sizes that can better represent horizontal two-phase flows.

TASK 5: Report Preparation and Submission

Task 5 prepares and submits the Financial Reports (SF-425) and the Performance Progress Reports (SF-PPR-B, SF-PPR-E) and the Final Performance Progress Report. These include: (1) Quarterly Federal Financial Reports (SF-425) for the periods ending 03/31, 06/30, 09/30 and 12/31. (b) Quarterly Performance Progress Reports (SF-PPR, B and E) for the periods ending 03/31, 06/30, 09/30 and 12/31. (c) Final Performance Progress Report (SF-PPR, B and E) and Final Federal Financial Report (SF-425) within 90-days after the project is expired.

Attachment C – Standard Terms and Conditions

The Nuclear Regulatory Commission's
Standard Terms and Conditions for U.S. Nongovernmental Recipients

Preface

This award is based on the application submitted to, and as approved by, the Nuclear Regulatory Commission (NRC) under the authorization 42 U.S.C. § 2051(b), pursuant to section 31b and 141b of the Atomic Energy Act of 1954, as amended, and is subject to the terms and conditions incorporated either directly or by reference in the following:

- Grant program legislation and program regulation cited in this Grant and Cooperative Agreement.
- Restrictions on the expenditure of Federal funds in appropriation acts, to the extent those restrictions are pertinent to the award.
- Code of Federal Regulations/Regulatory Requirements – 2 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards.

Any inconsistency or conflict in terms and conditions specified in the award will be resolved according to the following order of precedence: public laws, regulations, applicable notices published in the Federal Register, Executive Orders (E.O.), Office of Management and Budget (OMB) Circulars, the NRC's Mandatory Standard Provisions, special award conditions, and standard award conditions.

Certifications and Representations: These terms incorporate the certifications and representations required by statute, executive order, or regulation that were submitted with the SF424B application through GRANTS.GOV.

I. Mandatory General Requirements
The order of these requirements does not make one requirement more important than any other requirement.

1. Applicability of 2 CFR Part 200
All provisions of 2 CFR Part 200 and all Standard Provisions attached to this grant/cooperative agreement are applicable to the Recipient and to sub-recipients which meet the definition of "Recipient" in 2 Part §200.86, unless a section specifically excludes a sub-recipient from coverage. The Recipient and any sub-recipients must, in addition to the assurances made as part of the application, comply and require each of its sub-awardees employed in the completion of the project to comply with Subpart D of 2 CFR Part 200 and include this term in lower-tier (sub-award) covered transactions.

Recipients must comply with monitoring procedures and audit requirements in accordance with 2 CFR Part 200, Subpart F—AUDIT REQUIREMENTS.

2. Award Package
The Recipient is obligated to conduct project oversight as may be appropriate, to manage the funds with prudence, and to comply with the provisions outlined in 2 CFR Part 200. Within this framework, the Principal Investigator (PI) named on the award face page, is responsible for the scientific or technical direction of the project and for preparation of the project performance reports. This award is funded on a cost-reimbursement basis, not to exceed the amount awarded as indicated on the face page, and is subject to a refund of unexpended grant funds to the NRC.
The non-Federal entity alone must be responsible, in accordance with good administrative practice and sound business judgment, for the settlement of all contractual and administrative issues arising out of procurements related to its grant award. These issues include, but are not limited to, source evaluation, protests, disputes, and claims. These standards do not relieve the non-Federal entity of any financial or fiduciary responsibilities or obligations arising under its grant, including sub-contracts and sub-awards, or any other contractual or financial obligation. The Federal awarding agency will not substitute its judgment for that of the non-Federal entity unless the matter is primarily a Federal concern. Violations of law will be referred to the local, State, or Federal authority having proper jurisdiction. See 2 CFR § 200.318(k), General Procurement Standards.

Subawards
Appendix II to Part 200 Contract Provisions for Non-Federal Entity Contracts Under Federal Awards

Sub-recipients, sub-awardees, and contractors have no relationship with NRC under the terms of this grant/cooperative agreement. All required NRC approvals must be directed through the Recipient to NRC. See 2 CFR § 200.318.

Nondiscrimination
This provision is applicable when work under the grant/cooperative agreement is performed in the U.S. or when employees are recruited in the U.S.

The Recipient agrees to comply with the non-discrimination requirements below:

- Title VI of the Civil Rights Act of 1964 (42 U.S.C. §§ 2000d et seq.), which prohibits discrimination on the grounds of race, color, or national origin in any program or activity receiving federal financial assistance.

- Title IX of the Education Amendments of 1972 (20 U.S.C. §§ 1681 et seq.), which prohibits discrimination on the basis of sex in any education program or activity receiving federal financial assistance.
- Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. § 794), which prohibits discrimination on the basis of disability in any program or activity receiving federal financial assistance.
- The Age Discrimination Act of 1975, as amended (42 U.S.C. §§ 6101 et seq.), which prohibits discrimination on the basis of age in any program receiving federal financial assistance.
- The Americans with Disabilities Act of 1990 (42 U.S.C. §§ 12101 et seq.), which prohibits recipients from discriminating on the basis of disability in employment (Title I); State and local government services (Title II); and places of public accommodation and commercial facilities (Title III).
- Parts II and III of E.O. 11246, as amended by E.O.11375, 11478, 12086, 12107, 13279, 13665, and 13672, which prohibits federal contractors and federally assisted construction contractors and subcontractors, who do over $10,000 in Government business in one year, from discriminating in employment decisions on the basis of race, color, religion, sex, or national origin and requires that government contractors take affirmative action to ensure that equal opportunity is provided in all aspects of their employment.
- E.O.13166, "Improving Access to Services for Persons with Limited English Proficiency," which clarifies that national origin discrimination under Title VI includes discrimination on the basis of limited English proficiency (LEP) and requires that the recipient take reasonable steps to ensure that LEP persons have meaningful access to programs and activities.
- Any other applicable non-discrimination law(s).

Generally, Title VII of the Civil Rights Act of 1964, 42 U.S.C. § 2000e et seq, provides that it shall be an unlawful employment practice for an employer to discharge any individual or otherwise to discriminate against an individual with respect to compensation, terms, conditions, or privileges of employment because of such individual's race, color, religion, sex, or national origin. However, Title VII, 42 U.S.C. § 2000e-1(a), expressly exempts from the prohibition against discrimination on the basis of religion, a religious corporation, association, educational institution, or society with respect to the employment of individuals of a particular religion to perform work connected with the carrying on by such corporation, association, educational institution, or society of its activities.

Modifications/Prior Approval

NRC's prior written approval may be required before a Recipient makes certain budget modifications or undertakes particular activities. If NRC approval is required for changes in the grant or cooperative agreement, it must be requested and obtained from the NRC Grants Officer in advance of the change or obligation of funds. All requests for NRC prior approval, including requests for extensions to the period of performance, must be made, in writing (which includes submission by e-mail), to the designated Grants Officer at least 30 days before the proposed change. The request must be signed by the authorized organizational official. Failure to obtain prior approval, when required, from the NRC Grants Officer, may result in the disallowance of costs, or other enforcement action within NRC's authority.

Lobbying Restrictions

The Recipient will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§ 1501-1508 and 7324-7328) which limits the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

The Recipient will comply with provisions of 31 U.S.C § 1352. This provision generally prohibits the use of Federal funds for lobbying in the Executive or Legislative Branches of the Federal Government in connection with the award, and requires disclosure of the use of non-Federal funds for lobbying.

The Recipient receiving in excess of $100,000.00 in Federal funding shall submit a completed Standard Form (SF-LLL), "Disclosure of Lobbying Activities." The form concerns the use of non-Federal funds for lobbying within 30 days following the end of the calendar quarter in which there occurs any event that requires disclosure or that materially affects the accuracy of the information contained in any disclosure form previously filed. The Recipient must submit the SF-LLL, including those received from sub-recipients, contractors, and subcontractors, to the Grants Officer.

Debarment And Suspension – (See 2 CFR Part 180; 2 CFR § 200.205; 2 CFR § 200.113; and 2 CFR Part 200, Appendix II.)

The Recipient agrees to notify the Grants Officer immediately upon learning that it or any of its principals:

(1) Are presently excluded or disqualified from covered transactions by any Federal department or agency;

(2) Have been convicted within the preceding three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, tax evasion, receiving stolen property, making false claims, or obstruction of justice; commission of any other offense indicating a lack of business integrity or business honesty that seriously and directly affects your present responsibility;

(3) Are presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State, or local) with commission of any of the offenses enumerated in paragraph (1)(b); or

(4) Have had one or more public transactions (Federal, State, or local) terminated for cause or default within the preceding three years.

(5) The Recipient agrees that, unless authorized by the Grants Officer, it will not knowingly enter into any subaward or contracts under this grant/cooperative agreement with a person or entity that is not included on the System for Award Management (SAM) (https://www.sam.gov).

The Recipient further agrees to include the following provision in any subaward or contracts entered into under this award:

'Debarment, Suspension, Ineligibility, and Voluntary Exclusion

The Recipient certifies that neither it nor its principals is presently excluded or disqualified from participation in this transaction by any Federal department or agency. The policies and procedures applicable to debarment, suspension, and ineligibility under NRC-financed transactions are set forth 2 CFR Part 180 and 2 CFR Part 200.

Drug-Free Workplace
The Recipient must be in compliance with The Federal Drug Free Workplace Act of 1988. The policies and procedures applicable to violations of these requirements are set forth in 41 U.S.C. §§ 8101-8106.

Implementation of E.O.13224 – Executive Order on Terrorist Financing
The Recipient is reminded that U.S. Executive Orders and U.S. law prohibits transactions with, and the provision of resources and support to, individuals and organizations associated with terrorism. It is the legal responsibility of the Recipient to ensure compliance with these Executive Orders and laws. This provision must be included in all contracts/sub-awards issued under this grant/cooperative agreement.

The Recipient must comply with E.O. 13224, Blocking Property and Prohibiting Transactions with Persons who Commit, Threaten to Commit, or Support Terrorism. Information about this Executive Order can be found at:
Implementation of Executive Order 13224 Blocking Property and Prohibiting Transactions With Persons Who Commit, Threaten To Commit, or Support Terrorism , amended by E.O. 13268, 13284, and 13372.

Procurement Standards - 2 CFR §§ 200.318-200.326
Sections 200.318 - 200.326 set forth standards for use by Recipients in establishing procedures for the procurement of supplies and other expendable property, equipment, real property and other services with Federal funds. These standards are furnished to ensure that such materials and services are obtained in an effective manner and in compliance with the provisions of applicable Federal statutes and executive orders. No additional procurement standards or requirements will be imposed by the Federal awarding agencies upon Recipients, unless specifically required by Federal statute, executive order, or approved by OMB.

Travel and Transportation
Travel must be in accordance with the Recipient's Travel Regulations or the U.S. Government Travel Policy and Regulations at: www.gsa.gov/federaltravelregulation and the per diem rates set forth at: www.gsa.gov/perdiem, absent Recipient's travel regulations. Travel and transportation costs for the grant must be consistent with provisions as established in 2 CFR § 200.473-474.

All other travel, domestic or international, must not increase the total estimated award amount for the grant.

Domestic Travel:
Domestic travel is an appropriate charge to this award and prior authorization for specific trips are not required, if the trip is identified in the Recipient's approved program description and approved budget. Domestic trips not stated in the approved budget require the written prior approval of the Grants Officer, and must not increase the total estimated award amount for the grant.

All common carrier travel reimbursable hereunder shall be via the least expensive class rates consistent with achieving the objective of the travel and in accordance with the Recipient's policies and practices. Travel by first-class travel is not authorized unless prior approval is obtained, in writing, from the Grants Officer.

International Travel:
International travel requires **PRIOR** written approval by the Project Officer and the Grants Officer, even if the international travel is stated in the approved program description and the approved budget.

The Recipient will comply with the provisions of the Fly America Act (49 U.S.C 40118), as implemented at 41 CFR §§ 301-10.131 through 301-10.143.

Property Standards
Property standards of this award shall follow provisions as established 2 CFR §§ 200.310-200.316.

Intangible Property
Intangible and intellectual property of this award shall generally follow provisions established in 2 CFR § 200.315.

Inventions Report - The Bayh-Dole Act (P.L. 96-517) affords Recipients the right to elect and retain title to inventions they develop with funding under an NRC grant award ("subject inventions"). In accepting an award, the Recipient agrees to comply with applicable NRC policies, the Bayh-Dole Act, and its Government-wide implementing regulations found at Title 37, Code of Federal Regulations (CFR) Part 401. A significant part of the regulations require that the Recipient report all subject inventions to the awarding agency (NRC) as well as include an acknowledgement of federal support in any patents.

Patent Notification Procedures - If the NRC or its Recipients, without making a patent search, knows (or has demonstrable reasonable grounds to know) that technology covered by a valid United States patent has been or will be used without a license from the owner, E.O.12889 requires NRC to notify the owner. If the Recipient uses or has used patented technology under this award without license or permission from the owner, the Recipient must notify the Grants Officer. This notice does not imply that the Government authorizes and consents to any copyright or patent infringement occurring under the financial assistance.

Data, Databases, and Software - The rights to any work produced or purchased under a NRC federal financial assistance award, such as data, databases or software are determined by Subpart D of 2 CFR Part 200. The Recipient owns any work produced or purchased under a NRC federal financial assistance award subject to NRC's right to obtain, reproduce, publish or otherwise use the work or authorize others to receive, reproduce, publish or otherwise use the data for Government purposes.

Copyright - The Recipient may copyright any work produced under a NRC federal financial assistance award subject to NRC's royalty-free nonexclusive and irrevocable right to reproduce, publish or otherwise use the work or authorize others to do so for Government purposes. Works jointly authored by NRC and Recipient employees may be copyrighted, but only the part authored by the Recipient is protected because, under 17 U.S.C. § 105, works produced by Government employees are not copyrightable in the United States. On occasion, NRC may ask the Recipient to transfer to NRC its copyright in a particular work when NRC is undertaking the primary dissemination of the work. Ownership of copyright by the Government through assignment is permitted under 17 U.S.C. § 105.

Record Retention and Access
Recipient shall follow established provisions in 2 CFR §§ 200.333-337.

Conflict Of Interest

Conflict of Interest standards for this award will follow the Organizational Conflict of Interest (OCOI) requirements set forth in Section 170A of the Atomic Energy Act of 1954, as amended, and provisions set forth at 2 CFR § 200.112, Conflict of Interest.

Dispute Review Procedures

a. Any request for review of a notice of termination or other adverse decision should be addressed to the Grants Officer. It must be postmarked or transmitted electronically no later than 30 days after the postmarked date of such termination or adverse decision from the Grants Officer.

b. The request for review must contain a full statement of the Recipient's position and the pertinent facts and reasons in support of such position.

c. The Grants Officer will promptly acknowledge receipt of the request for review and shall forward it to the Director, Office of Acquisition Management Division, unless otherwise delegated, who shall appoint an intra-agency Appeal Board to review a recipient appeal of an agency action, if required, which will consist of the program office director, the Deputy Director of Office of Administration, and the Office of General Counsel.

d. Pending resolution of the request for review, the NRC may withhold or defer payments under the award during the review proceedings.

e. The review committee will request the Grants Officer who issued the notice of termination or adverse action to provide copies of all relevant background materials and documents. The committee may, at its discretion, invite representatives of the Recipient and the NRC program office to discuss pertinent issues and to submit such additional information as it deems appropriate. The chairman of the review committee will insure that all review activities or proceedings are adequately documented.

f. Based on its review, the committee will prepare its recommendation to the Director, Office of Administration, who will advise the parties concerned of his/her decision.

Remedies for Noncompliance

Termination of this award will follow provisions as established and described above in "Dispute Review Process" in 2 CFR §§ 200.338-342.

Performance and Financial Monitoring and Reporting - 2 CFR §§ 200.327-329

Recipient Financial Management systems must comply with the provisions in 2 CFR § 200.302.

- Payment – 2 CFR § 200.305
- Cost Share or Matching – 2 CFR § 200.306
  - Recipients are to be careful with providing excessive cost share or match since at the end of the grant, if the identified match has not been provided, then a portion of the federal share may be required to be returned to the Government.
- Program Income – 2 CFR § 200.307
  - Earned program income, if any, will be added to funds committed to the project by the NRC and Recipient and used to further eligible project or program objectives or be deducted from the total project cost for the grant, as directed by the Grants Officer or indicated in the terms and conditions of the award.

- Revision of Budget and Program Plans – 2 CFR § 200.308

- The Recipient is required to report deviations from the approved budget and program descriptions in accordance with – 2 CFR § 200.308(b) and request prior written approval from the Project Officer and the Grants Officer.
- The Recipient is not authorized to re-budget between direct costs and indirect costs without written prior approval of the Grants Officer.
- The Recipient is authorized to transfer funds among direct cost categories up to a cumulative 10 percent of the total approved budget. The Recipient is not allowed to transfer funds if the transfer would cause any Federal appropriation to be used for purposes other than those consistent with the original intent of the appropriation.
- Allowable Costs – 2 CFR §§ 200.401-403

- See section 2 CFR §§ 200.330-332 for Subrecipient Monitoring and Management.

Federal Financial Reports - In accordance with 2 CFR § 200.327, the Recipient will submit a "Federal Financial Report" (SF-425) on a quarterly basis for the periods ending March 31, June 30, September 30, and December 31, or any portion thereof, unless otherwise authorized by the Grants Officer. Reports are due no later than 30 days following the end of each reporting period. A final SF-425 is due within 90 days after expiration of the award. The report should be submitted electronically to:

1. Grants_FFR.Resource@NRC.gov (NOTE: There is an underscore between Grants and FFR);
2. RESGrants.Resource@NRC.gov;
3. Technical Analyst; and
4. Grants Officer.

Performance Progress Reports - In accordance with 2 CFR § 200.328, the Recipient will submit Performance Progress Reports (SF-PPR, SF-PPR-B, and the SF-PPR-E) on a quarterly basis for the periods ending March 31, June 30, September 30, and December 31, or any portion thereof, unless otherwise authorized by the Grants Officer. Reports are due no later than 30 days following the end of the reporting period. The report should be submitted electronically to:

1. Grants_PPR.Resource@NRC.gov (NOTE: There is an underscore between Grants and PPR);
2. RESGrants.Resource@NRC.gov;
3. Technical Analyst; and
4. Grants Officer.

Final Reports - The Recipient is required to submit final reports, both Financial (SF-425) and Performance (SF-PPR, SF-PPR-B, SF-PPR-E) within 90 days of the grant expiration. In addition to these reports, a final SF-428, Tangible property report, is also required, if applicable.

Period of Performance – 2 CFR § 200.309
The recipient may charge to the Federal award only allowable costs incurred during the period of performance and any costs incurred before the NRC or pass-through entity made the Federal award that was authorized by the NRC or pass through entity.

Unless otherwise authorized in 2 CFR Part 200 or by special award condition, any extension of the award period can only be authorized by the Grants Officer in writing. Assurances of funding

from other than the Grants Officer shall not constitute authority to obligate funds for programmatic activities beyond the expiration date.

The NRC Grant Officer may authorize a no cost extension of the period of performance. However, the NRC has no obligation to provide any additional prospective or incremental funding. Any modification of the award to increase funding and to extend the period of performance is at the sole discretion of the NRC.

Automated Standard Application For Payments (ASAP) Procedures
Unless otherwise stated, Recipient payments are made using the Department of Treasury's Automated Standard Application for Payment (ASAP) system, ASAP.gov, through preauthorized electronic funds transfers. To receive payments, Recipients are required to enroll with the Department of Treasury, Financial Management Service, and Regional Financial Centers, which allows them to use the on-line method of withdrawing funds from their ASAP established accounts. The following information is required to make ASAP withdrawals: (1) ASAP account number – the award number found on the cover sheet of the award; (2) Agency Location Code (ALC) – 31000001; and Region Code. Recipients enrolled in the ASAP system do not need to submit a "Request for Advance or Reimbursement" (SF-270).

II. Audit Requirements

Audits
Organization-wide or program-specific audits are performed in accordance with the Single Audit Act of 1996, as amended, and as implemented by 2 CFR Part 200, Subpart F—AUDIT REQUIREMENTS. Recipients are subject to the provisions of this subpart if they expend $750,000 or more in a year in Federal awards. See 2 CFR 2 CFR § 200.501.

The Form SF-SAC and the Single Audit Reporting packages for fiscal periods ending on or after January 1, 2008 are submitted online, as follows:

1. Create your online report ID at: http://harvester.census.gov/fac/collect/ddeindex.html;
2. Complete the Form SF-SAC;
3. Upload the Single Audit;
4. Certify the Submission; and
5. Click "Submit."

Organizations expending less than $750,000 a year are not required to have an annual audit for that year but must make their grant-related records available to NRC or other designated officials for review or audit.

III. Programmatic Requirements

Unsatisfactory Performance
Failure to perform the work in accordance with the terms of the award and maintain at least a satisfactory performance rating may result in designation of the Recipient as high risk and the assignment of special award conditions. Further action may be required as specified in the standard term and condition entitled "Remedies for Noncompliance."

Failure to comply with the award provisions may result in a negative impact on future NRC funding. In addition, the Grants Officer may withhold payments; change the method of payment from advance to reimbursement; impose special award conditions; suspend or terminate the grant.

Other Federal Awards With Similar Programmatic Activities
The Recipient will immediately notify the Project Officer and the Grants Officer in writing if after award, other financial assistance is received to support or fund any portion of the program description stated in the NRC award. NRC will not pay for costs that are funded by other sources.

Prohibition Against Assignment By The Recipient
The Recipient will not transfer, pledge, mortgage, or otherwise assign the award, or any interest to the award, or any claim arising under the award, to any party, banks, trust companies, or other financing or financial institutions without the written approval of the Grants Officer.

Site Visits
The NRC, through authorized representatives, has the right to make site visits to review project accomplishments and management control systems and to provide technical assistance as required. If any site visit is made by the NRC on the premises of the Recipient or contractor under an award, the Recipient shall provide and shall require his/her contractors to provide reasonable access to all facilities and provide necessary assistance for the safety and convenience of the Government representative in the performance of his/her official duties.

IV. Miscellaneous Requirements

Criminal and Prohibited Activities
The Program Fraud Civil Remedies Act (31 U.S.C. §§ 3801-3812), provides for the imposition of civil penalties against persons who make false, fictitious, or fraudulent claims to the Federal government for money (including money representing grant/cooperative agreements, loans, or other benefits).

False statements (18 U.S.C. § 287), provides that whoever makes or presents any false, fictitious, or fraudulent statements, representations, or claims against the United States shall be subject to imprisonment of not more than five years and shall be subject to a fine in the amount provided by 18 USC §287.

False Claims Act (31 U.S.C. § 3729 et seq.), provides that suits under this Act can be brought by the government, or a person on behalf of the government, for false claims under federal assistance programs.

Copeland "Anti-Kickback" Act (18 U.S.C. § 874), prohibits a person or organization engaged in a federally supported project from enticing an employee working on the project from giving up a part of his compensation under an employment contract.

American-Made Equipment And Products
Recipients are encouraged to purchase American-made equipment and products with funding provided under this award.

Increasing Seat Belt Use in the United States
E.O. 13043, amended by E.O. 13652, requires Recipients to encourage employees and contractors to enforce on-the-job seat belt policies and programs when operating company-owned, rented or personally-owned vehicle.

Federal Leadership of Reducing Text Messaging While Driving
E.O. 13513 requires Recipients to encourage employees, sub-awardees, and contractors to adopt and enforce policies that ban text messaging while driving company-owned, rented

vehicles or privately owned vehicles when on official Government business or when performing any work for or on behalf of the Federal Government.

Federal Employee Expenses

Federal agencies are barred from accepting funds from a Recipient to pay transportation, travel, or other expenses for any Federal employee unless specifically approved in the terms of the award. Use of award funds (Federal or non-Federal) or the Recipient's provision of in-kind goods or services, for the purposes of transportation, travel, or any other expenses for any Federal employee may raise appropriation augmentation issues. In addition, NRC policy prohibits the acceptance of gifts, including travel payments for Federal employees, from Recipients or applicants regardless of the source.

Minority Serving Institutions (MSIs) Initiative

Pursuant to E.O.s 13230 and 13270, amended by E.O. 13316 and 13385, 13532, 13592, 13555, 13515, and 13621, NRC is strongly committed to broadening the participation of MSIs in its financial assistance program. NRC's goals include achieving full participation of MSIs in order to advance the development of human potential, strengthen the Nation's capacity to provide high-quality education, and increase opportunities for MSIs to participate in and benefit from Federal financial assistance programs. NRC encourages all applicants and Recipients to include meaningful participations of MSIs. Institutions eligible to be considered MSIs are listed on the Department of Education website: http://www.ed.gov/about/offices/list/ocr/edlite-minorityinst.html

Research Misconduct

Scientific or research misconduct refers to the fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results. It does not include honest errors or differences of opinions. The Recipient organization has the primary responsibility to investigate allegations and provide reports to the Federal Government. Funds expended on an activity that is determined to be invalid or unreliable because of scientific misconduct may result in a disallowance of costs for which the institution may be liable for repayment to the awarding agency. The Office of Science and Technology Policy at the White House published in the Federal Register on December 6, 2000, a final policy that addressed research misconduct. The policy was developed by the National Science and Technology Council (65 FR 76260). The NRC requires that any allegation be submitted to the Grants Officer, who will also notify the OIG of such allegation. Generally, the Recipient organization shall investigate the allegation and submit its findings to the Grants Officer. The NRC may accept the Recipient's findings or proceed with its own investigation. The Grants Officer shall inform the Recipient of the NRC's final determination.

Publications, Videos, and Acknowledgment of Sponsorship

Publication of the results or findings of a research project in appropriate professional journals and production of video or other media is encouraged as an important method of recording and reporting scientific information. It is also a constructive means to expand access to federally funded research. The Recipient is required to submit a copy to the NRC and when releasing information related to a funded project include a statement that the project or effort undertaken was or is sponsored by the NRC. The Recipient is also responsible for assuring that every publication of material (including Internet sites and videos) based on or developed under an award, except scientific articles or papers appearing in scientific, technical or professional journals, contains the following disclaimer:

"This **[report/video]** was prepared by **[Recipient name]** under award **[number]** from **[name of operating unit]**, Nuclear Regulatory Commission. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the view of the **[name of operating unit]** or the US Nuclear Regulatory Commission."

Trafficking In Victims Protection Act Of 2000 (as amended by the Trafficking Victims Protection Reauthorization Act of 2003)

Section 106(g) of the Trafficking In Victims Protection Act Of 2000 (as amended as amended, directs on a government-wide basis that:

> "...any grant, contract, or cooperative agreement provided or entered into by a Federal department or agency under which funds are to be provided to a private entity, in whole or in part, shall include a condition that authorizes the department or agency to terminate the grant, contract, or cooperative agreement, without penalty, if the recipient or any subrecipient, or the contractor or any subcontractor (i) engages in severe forms of trafficking in persons or has procured a commercial sex act during the period of time that the grant, contract, or cooperative agreement is in effect, or (ii) uses forced labor in the performance of the grant, contract, or cooperative agreement." (See 22 U.S.C. §7104(g).)

EXECUTIVE COMPENSATION REPORTING

2 CFR § 170.220 directs agencies to include the following text to each grant award to a non-federal entity if the total funding is $25,000 or more in Federal funding.

Reporting Subawards and Executive Compensation.

a. *Reporting of first-tier subawards.*

1. *Applicability.* Unless you are exempt as provided in paragraph d. of this award term, you must report each action that obligates $25,000.00 or more in Federal funds that does not include Recovery funds (as defined in section 1512(a)(2) of the American Recovery and Reinvestment Act of 2009, Pub. L. 111–5) for a subaward to an entity (see definitions in paragraph e. of this award term).

2. *Where and when to report.*

i. You must report each obligating action described in paragraph a.1. of this award term to *http://www.fsrs.gov*.

ii. For subaward information, report no later than the end of the month following the month in which the obligation was made. (For example, if the obligation was made on November 7, 2010, the obligation must be reported by no later than December 31, 2010.)

3. *What to report.* You must report the information about each obligating action that the submission instructions posted at *http://www.fsrs.gov* specify.

b. *Reporting Total Compensation of Recipient Executives.*

1. *Applicability and what to report.* You must report total compensation for each of your five most highly compensated executives for the preceding completed fiscal year, if—

i. the total Federal funding authorized to date under this award is $25,000.00 or more;

ii. in the preceding fiscal year, you received—

(A) 80 percent or more of your annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR § 170.320 (and subawards); and

(B) $25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR § 170.320 (and subawards); and

iii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at *http://www.sec.gov/answers/execomp.htm*.)

2. *Where and when to report.* You must report executive total compensation described in paragraph b.1. of this award term:

i. As part of your registration profile at *http://www.sam.gov* .

ii. By the end of the month following the month in which this award is made, and annually thereafter.

c. *Reporting of Total Compensation of Subrecipient Executives.*

1. *Applicability and what to report.* Unless you are exempt as provided in paragraph d. of this award term, for each first-tier subrecipient under this award, you shall report the names and total compensation of each of the subrecipient's five most highly compensated executives for the subrecipient's preceding completed fiscal year, if—

i. in the subrecipient's preceding fiscal year, the subrecipient received—

(A) 80 percent or more of its annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR § 170.320 (and subawards); and

(B) $25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts), and Federal financial assistance subject to the Transparency Act (and subawards); and

ii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at *http://www.sec.gov/answers/execomp.htm*.)

2. *Where and when to report.* You must report subrecipient executive total compensation described in paragraph c.1. of this award term:

i. To the recipient.

ii. By the end of the month following the month during which you make the subaward. For example, if a subaward is obligated on any date during the month of October of a given year (*i.e.,* between October 1 and 31), you must report any required compensation information of the subrecipient by November 30 of that year.

d. *Exemptions*

If, in the previous tax year, you had gross income, from all sources, under $300,000.00, you are exempt from the requirements to report:

i. Subawards,

and

ii. The total compensation of the five most highly compensated executives of any subrecipient.

e. *Definitions.* For purposes of this award term:

1. *Entity* means all of the following, as defined in 2 CFR Part 25:

i. A Governmental organization, which is a State, local government, or Indian tribe;

ii. A foreign public entity;

iii. A domestic or foreign nonprofit organization;

iv. A domestic or foreign for-profit organization;

v. A Federal agency, but only as a subrecipient under an award or subaward to a non-Federal entity.

2. *Executive* means officers, managing partners, or any other employees in management positions.

3. *Subaward:*

i. This term means a legal instrument to provide support for the performance of any portion of the substantive project or program for which you received this award and that you as the recipient award to an eligible subrecipient.

ii. The term does not include your procurement of property and services needed to carry out the project or program (for further explanation, see Sec. __ .210 of the attachment to OMB Circular A–133, "Audits of States, Local Governments, and Non-Profit Organizations)

iii. A subaward may be provided through any legal agreement, including an agreement that you or a subrecipient considers a contract.

4. *Subrecipient* means an entity that:

i. Receives a subaward from you (the recipient) under this award; and

ii. Is accountable to you for the use of the Federal funds provided by the subaward.

5. *Total compensation* means the cash and noncash dollar value earned by the executive during the recipient's or subrecipient's preceding fiscal year and includes the following (for more information see 17 CFR § 229.402(c)(2)):

i. *Salary and bonus.*

ii. *Awards of stock, stock options, and stock appreciation rights.* Use the dollar amount recognized for financial statement reporting purposes with respect to the fiscal year in accordance with the Statement of Financial Accounting Standards No. 123 (Revised 2004) (FAS 123R), Shared Based Payments.

iii. *Earnings for services under non-equity incentive plans.* This does not include group life, health, hospitalization or medical reimbursement plans that do not discriminate in favor of executives, and are available generally to all salaried employees.

iv. *Change in pension value.* This is the change in present value of defined benefit and actuarial pension plans.

v. *Above-market earnings on deferred compensation which is not tax-qualified.*

vi. Other compensation, if the aggregate value of all such other compensation (e.g., severance, termination payments, value of life insurance paid on behalf of the employee, perquisites or property) for the executive exceeds $10,000.00.