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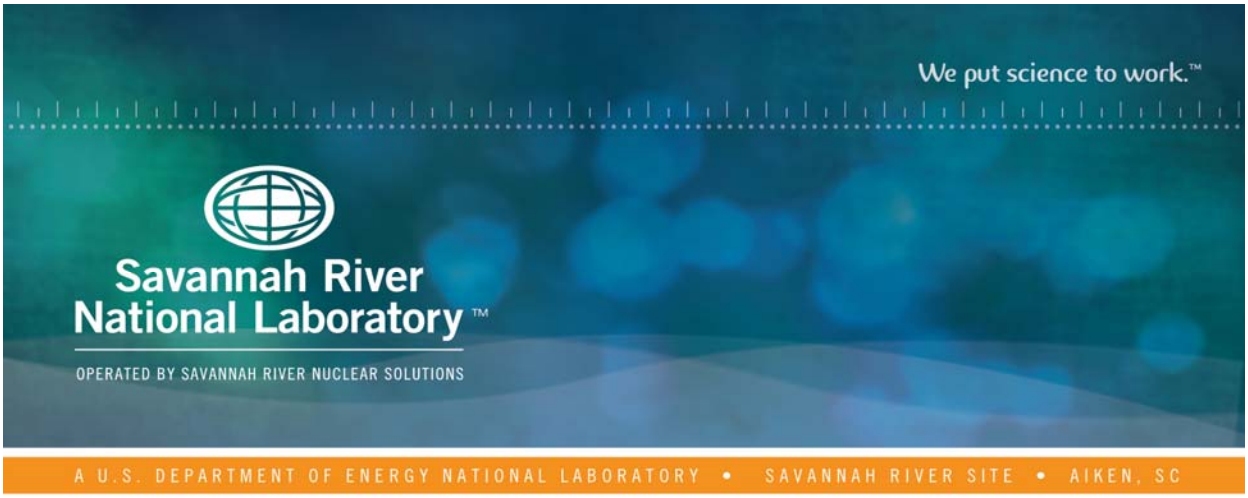

Dissolution of Low Enriched Uranium from the Experimental Breeder Reactor-II Fuel Stored at the Idaho National Laboratory

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EXECUTIVE SUMMARY

The Idaho National Laboratory (INL) is actively engaged in the development of electrochemical processing technology for the treatment of fast reactor fuels using irradiated fuel from the Experimental Breeder Reactor-II (EBR-II) as the primary test material. The research and development (R&D) activities generate a low enriched uranium (LEU) metal product from the electrorefining of the EBR-II fuel and the subsequent consolidation and removal of chloride salts by the cathode processor. The LEU metal ingots from past R&D activities are currently stored at INL awaiting disposition. One potential disposition pathway is the shipment of the ingots to the Savannah River Site (SRS) for dissolution in H-Canyon. Carbon steel cans containing the LEU metal would be loaded into reusable charging bundles in the H-Canyon Crane Maintenance Area and charged to the 6.4D or 6.1D dissolver. The LEU dissolution would be accomplished as the final charge in a dissolver batch (following the dissolution of multiple charges of spent nuclear fuel (SNF)). The solution would then be purified and the ^{235}U enrichment down-blended to allow use of the U in commercial reactor fuel. To support this potential disposition path, the Savannah River National Laboratory (SRNL) developed a dissolution flowsheet for the LEU using samples of the material received from INL.

A dissolution flowsheet for the LEU ingots generated at the INL from the electrochemical processing of the EBR-II fuel was demonstrated at the laboratory scale. Dissolution experiments were performed using samples of the LEU and a carbon steel can and an integrated experiment was performed in which an Al 1100 alloy was dissolved as a surrogate for SNF followed by the dissolution of samples of the LEU and carbon steel can to demonstrate the complete flowsheet. The flowsheet allows the dissolution of a SNF batch in an H-Canyon dissolver using existing flowsheets followed by the dissolution of nominally 75 kg of LEU in the 6.4D dissolver or 45 kg of LEU in the 6.1D dissolver which were recovered from the EBR-II fuel. In the demonstration experiment, the rate of dissolution of the LEU metal was significantly slower than the dissolution rate of the Al 1100 alloy (4.7 mg/min/cm^2 versus 27 mg/min/cm^2) which projects to a longer cycle time for the LEU metal (compared to a SNF charge). The H_2 generation rate from the dissolution of samples of the LEU metal and a carbon steel can were monitored by mass spectrometry and Raman spectroscopy and were shown to be inconsequential; therefore, the dissolution of the LEU ingots has no significant impact on the generation of H_2.

The LEU samples received from the INL contained up to approximately 1000 µg Zr/g U (0.1 wt %). A potential concern during the HNO_3 dissolution of U metal containing Zr is the explosive behavior that has been reported for alloys of these materials. Uranium-zirconium alloys with 1-50 wt % Zr will contain some amount of the highly reactive epsilon phase; however, concentrations below 1 wt % Zr have not resulted in violent dissolution behavior. No violent exothermic behavior was observed during the dissolution of any pieces of the LEU samples from the INL ingots. The presence of chloride salts from the INL electrorefiner which are associated with the LEU ingots are a potential H-Canyon corrosion concern. The concentration of chloride in solutions from the dissolution of samples of the LEU were less than the detection limit (100 µg/mL); however, the chloride salts associated with the LEU samples may not be a good measure of the chloride salts associated with the ingots due to the sample casting operation. Monitoring the chloride concentration in the dissolver during the LEU dissolution campaign is recommended due to the potential for the ingots to be associated with chloride salts from the INL electrorefiner.

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LIST OF ABBREVIATIONS

EBR-II	Experimental Breeder Reactor-II
ICPES	inductively-coupled plasma emission spectroscopy
ICPMS	inductively-coupled plasma mass spectroscopy
INL	Idaho National Laboratory
HFIR	High Flux Isotope Reactor
LFL	lower flammability limit
LEU	low enriched uranium
MTR	Material Test Reactor
R&D	research and development
RPM	revolutions per minute
SNF	spent nuclear fuel
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions
SRS	Savannah River Site
U-5Fs	uranium 5 wt % fissium

1.0 Introduction

The INL has been active in the development of pyroprocessing technology since the 1980's. The R&D activities have included two primary missions: treatment of the spent fuel from the EBR-II and the development of advanced technology to assist in the closure of the nuclear fuel cycle. The electrorefiner is the key unit operation in pyroprocessing. It is where the U in the spent fuel is electrochemically separated from the cladding hulls, sodium bond, and noble metals. The U product from the electrorefiner is in dendritic form and is coated with chloride salts. After removal from the electrorefiner, the U is loaded into the cathode processor where the U is melted and nearly all of the salt removed by distillation. The U product is then transferred from the cathode processor to a receiver crucible for solidification.[1] The U ingots, which contain less than 20 wt % U-235, are currently stored at the INL Fuel Conditioning Facility until a disposition pathway is selected.

Recent discussions between INL and Savannah River Nuclear Solutions (SRNS) personnel have identified a potential disposition pathway for the LEU ingots generated from the treatment of irradiated uranium 5 wt % fissium (U-5Fs) EBR-II fuel. The potential disposition pathway would include the shipment of LEU from the pyroprocessing of the fuel to the SRS for dissolution in H-Canyon. The U-5Fs fuel was an early generation fuel used in the EBR-II reactor from the 1960's through the late 1980's containing 95 wt % U metal alloyed with 5 wt % noble metals or "fissium" (2.5 wt % Mo, 2.0 wt % Ru, 0.3 wt % Rh, 0.1 wt % Pd, and 0.1 wt % Zr).[2] The LEU designated for dissolution in H-Canyon would be sealed in dissolvable nylon bags and placed in carbon steel cans in the same manner that is currently used for dissolution of Pu metal in the 6.1D dissolver to produce feed material for the HB-Line plutonium oxide production mission.[3] The cans would be loaded into reusable charging bundles in the H-Canyon Crane Maintenance Area and charged to an H-Canyon dissolver. The LEU dissolution would be accomplished as the final charge in a dissolver batch. Approximately 75 kg U (15 kg U-235) would be dissolved following the dissolution of a batch of SNF in the 6.4D dissolver and approximately 45 kg of U (9 kg of U-235) would be dissolved following the dissolution of a batch of SNF in the 6.1D dissolver. If the dissolvers are filled to their nominal working volume ranges, the U concentration following dissolution of the LEU charges would be approximately 8-12 g/L. To support the new mission, the SRNL was requested to develop a dissolution flowsheet for the LEU based on the receipt of four 25 g samples of the material from INL.[4]

Large pieces of U metal dissolve in HNO_3 at a moderate rate; however, as the surface area increases so does the metal dissolution rate.[5] The dissolution reaction is quite complicated, with the acid reduction products varying from nitrogen dioxide (NO_2) to elemental nitrogen. In general, dissolutions performed using 8 M HNO_3 or less generate nitric oxide (NO) as the principal gaseous product; those carried out at higher acidities produce NO_2 as the principal product.[6] The LEU from the EBR-II reactor will readily dissolve in an H-Canyon dissolver using HNO_3 concentrations in the 1-2 M range which are present in the solution following the dissolution of a batch of SNF. It may be necessary to add HNO_3 to the solution to ensure the final concentration is greater than 0.5 M. Although Hg would be present in the dissolver, it is not required to catalyze the LEU dissolution. As part of the flowsheet development, SRNL measured the dissolution rate of the LEU samples from INL to allow prediction of the dissolution cycle time.

The LEU ingots from INL are relatively pure U metal. All noble metal fission product elements in the EBR-II U-5Fs fuel are generally removed by the electrorefining process with the exception of Zr. Zirconium is present in the electrorefiner at a higher concentration from the processing of other fuel. Preliminary characterization data from the analysis of two ingots are shown in Table 1.

Table 1-1. Preliminary Characterization Data for U-5Fs Ingots[2]

Element	Units	Mean Value(1)
Al	ppm	<180
Cd	ppm	<15
C	ppm	~220
Cr	ppm	<50
Fe	ppm	123
Li	ppm	<10
Mn	ppm	14
Mo	ppm	<90
Ni	ppm	<20
N	ppm	<5
O	ppm	~130
Si	ppm	~125
Zr	ppm	681
Total U	wt %	99.9
U-235	wt %	19.7

(1) Mean value for two ingots

One element of potential concern in the LEU is the presence of Zr. Explosions, fires, vigorous to violent reactions, and other off-normal events involving the dissolution of U-Zr alloys in HNO_3 have been documented within the Department of Energy complex dating back to the 1950's.[7] It has been shown that exothermic reactions result from the rapid oxidation of finely divided solids released by the preferential dissolution of the U metal matrix. The explosive portion of such solids has been identified as an intermetallic compound with the approximate composition of UZr_2.[8] (Other researchers have cited UZr_3 as the stoichiometry and refer to the intermetallic compound as the epsilon phase in the U-Zr phase diagram.) If uniformly distributed throughout the LEU matrix, a low concentration of Zr should not be a concern during dissolution of the INL ingots. In a thorough investigation of the explosion of U-Zr alloys when treated with HNO_3, Larsen et al. concluded that depending on the composition, homogeneity, and previous thermal history, U-Zr alloys with 1-50 wt % Zr will contain some amount of the finely divided epsilon phase in a matrix of alpha-U.[9] Concentrations below 1 wt % (10,000 ppm) were not reported to exhibit exothermic behavior. To assess the uniformity of the Zr concentration in the LEU, multiple pieces of the samples received from INL were dissolved and analyzed for Zr.

The U product from the INL electrorefiner is in dendritic form and is coated with active metal chloride salts (typically 20 wt % of the product) before being transferred to cathode processing. In the cathode processor, the U and chloride salts are melted and the salts are removed by distillation. Over numerous runs during the treatment of EBR-II driver fuel, the distillation efficiency for the active metal salts ranged from about 98.6 to 99.96%.[1] The presence of chloride salts with the LEU ingot could potentially increase corrosion in the H-Canyon dissolver and downstream processing operations (e.g., high activity waste evaporation and acid recovery); although, the Hg present in the dissolving solution may precipitate chloride salts associated with the LEU ingots. When the scrub alloy from the Rocky Flats Plant was dissolved in F-Canyon to recover Pu from the reductive stripping of sodium/potassium chloride salts from the molten salt extraction process, mercuric nitrate was added to the dissolving solution prior to Head End centrifugation to precipitate the chloride.[10-11] The mercurous chloride precipitate would be removed during centrifugation and discarded as waste. Solutions generated from the dissolution of the LEU samples received from INL were analyzed for chloride; however, the potential for chloride contamination on the surface of the LEU ingots should be evaluated prior to dissolution in H-Canyon.

The generation of H_2 in the offgas during the dissolution of the LEU ingots must be shown to be below 60% of the lower flammability limit (LFL) for H_2.[12] A significant concentration of H_2 in the offgas from the LEU dissolution is not expected.[6] The dissolution of Al-clad, U-Al alloy fuels are known to generate H_2 during dissolution, however, the H_2 generation during dissolution of material and test reactor (MTR) or High Flux Isotope Reactor (HFIR) fuels is addressed by the existing H-Canyon flowsheets.[13,14] As part of the flowsheet development activities for the LEU ingots, SRNL characterized the offgas from the dissolution of samples of the LEU material received from INL. The results from these studies confirm that the amount of LEU specified for a dissolver batch can be dissolved without excessive reactivity and flammable gas generation.

Following dissolution of the MTR or HFIR fuels and LEU ingots, the U-containing solution will be processed through Head End and centrifuged to remove particulate matter. After Head End treatment, the U will be recovered and purified by solvent extraction (1st and 2nd U Cycles), and the waste processed for transfer to the H-Area Tank Farm. The enriched U from the MTR or HFIR fuels and LEU from the ingots will be down-blended for subsequent use as commercial reactor fuel.

2.0 Experimental Procedure

2.1 Surrogate Materials

In previous flowsheets developed for the dissolution of High Flux Isotope Reactor (HFIR)[14] and Material and Test Reactor (MTR) fuels[13], Daniel et al. demonstrated that Al 1100 provided a bounding estimate for the generation of H_2 and was subsequently used as a surrogate for these fuels. Although, the development of a new flowsheet is not required for the dissolution of SNF prior to the dissolution of LEU ingots in H-Canyon, an experimental Al 1100 dissolution was performed as part of the flowsheet demonstration. The Al 1100 dissolution was performed to simulate the dissolved fuel prior to dissolution of samples of the LEU and carbon steel from a food pack can. The food pack can was provided by H-Canyon Engineering and simulates the cans which would be used to ship the LEU ingots to SRS.

2.2 Dissolution Experiments for Offgas Characterization

The generation of H_2 in an H-Canyon dissolver must be demonstrated to be less than 60% of the LFL during dissolution of the LEU ingots.[12] To ensure this requirement is met, dissolution experiments were performed using an Al 1100 alloy coupon and samples of the LEU and a carbon steel can. The dissolution of the nylon bags used as primary containment for contamination control will not contribute any significant offgas to the dissolution process.[15] The flammable gas generation from a small piece of a carbon steel food pack can was previously evaluated for a Pu metal dissolution flowsheet. The results from this experiment (Experiment 86) are discussed in Section 3.1.2 of this report. Two additional experiments (Experiments 80 and 109) were performed to characterize the offgas from the dissolution of the LEU samples received from INL. In Experiment 80, a sample of the LEU received from INL was dissolved and in Experiment 109 a complete demonstration of the flowsheet was performed in which an Al 1100 alloy coupon was initially dissolved followed by samples of the LEU and a carbon steel can. The dissolution of the Al 1100 alloy coupon was performed using the same general flowsheet used in H-Canyon for the dissolution of MTR and HFIR fuel.[13,14] A summary of the objective and dissolution conditions for each experiment are provided in Table 2-1. All experiments were performed at the boiling point of the solution except for Experiment 86 which was performed at room temperature.

Table 2-1. Dissolution Experiments

Exp. No.(1)	Objective (Evaluate ...)	Material	Hg Conc. (M)	Target Al Conc. (M)
80	offgas generation at 7 M HNO_3	LEU	0	0
86	offgas generation at 10 M HNO_3, 1.5 g B/L, 0.1M KF	carbon steel	0	0
109-Phase 1	offgas generation rate with hold on Hg addition	Al 1100	0.002	1.6
109-Phase 2	offgas generation at 1.4 M HNO_3 and 4.3 g U/L	LEU, carbon steel	0.002	1.6

(1) Experimental numbering sequence corresponds to data recording practices

2.2.1 Preparation of Coupons

The Al 1100 alloy used in the dissolution experiment was prepared by cutting a corrosion coupon to the desired length. The coupon was lightly sanded, washed with soap and water to remove any residue, and then weighed and measured. The coupon was sanded to maximize reactivity as well as to generate consistent results.

The LEU used in the dissolution experiments was cut from samples provided by INL. The samples were rods with an approximate 3.0 mm diameter that were cut to lengths of approximately 25 mm. The cut samples were wiped clean and then weighed and measured prior to the dissolution. The carbon steel can coupon was cut from a carbon steel can supplied by H-Canyon Engineering. The coupon was weighed and measured prior to the dissolution.

The masses, dimensions, and surface areas of the coupons used in the experiments are provided in Table 2-2. The surface area calculations for the carbon steel can coupon are illustrated by equation 1,

$$\mathrm{SA}\left(\mathrm{cm}^2\right) = 2 \cdot w(\mathrm{cm}) \cdot \ell(\mathrm{cm}) + 2 \cdot t(\mathrm{cm}) \cdot \ell(\mathrm{cm}) + 2 \cdot w(\mathrm{cm}) \cdot t(\mathrm{cm}) \quad (1)$$

where SA is the surface area of the immersed coupon, and t is the thickness, w is the width, and ℓ is the length of the coupon. Since the carbon steel can coupon used in Experiment 86 had a 1/16 inch hole used to suspend it in the solution, the surface area was corrected to account for this geometry using equation (2),

$$\mathrm{SA}^*\left(\mathrm{cm}^2\right) = 2 \cdot \pi \cdot \left[\frac{d(\mathrm{cm})}{2}\right]^2 + \pi \cdot d(\mathrm{cm}) \cdot t(\mathrm{cm}) \quad (2)$$

where SA* is the surface area correction for the carbon steel can coupon to be subtracted from the surface area calculated by Equation 1, d is the hole diameter (0.15875 cm = 1/16 inch), and t is the thickness of the coupon.

The surface area of the Al 1100 coupon was based on a 10 mm immersion depth along the length of the coupon in the HNO_3 solution. The calculations are illustrated by equation 3,

$$\mathrm{SA}\left(\mathrm{cm}^2\right) = 2 \cdot (1\ \mathrm{cm}) \cdot t(\mathrm{cm}) + 2 \cdot (1\ \mathrm{cm}) \cdot w(\mathrm{cm}) + \mathrm{w(cm)} \cdot \mathrm{t(cm)} \quad (3)$$

where SA is the surface area of the immersed coupon, t is the thickness of the coupon, and w is the width of the coupon.

The surface area of the LEU coupons was based on the diameter and length as shown by equation 4,

$$\mathrm{SA}\left(\mathrm{cm}^2\right) = 2 \cdot \pi \cdot \left[\frac{\mathrm{d(cm)}}{2}\right]^2 + \pi \cdot \mathrm{d(cm)} \cdot \ell\mathrm{(cm)} \quad (4)$$

where SA is the surface area of the immersed coupon, d is the diameter of the coupon, and ℓ is the length of the coupon.

Table 2-2. Alloy Coupon Characteristics

Exp. No.[1]	Alloy	Mass	Length	Width	Thickness/ Diameter	Surface Area[2]
		(g)	(cm)	(cm)	(cm)	(cm^2)
80	LEU	2.8434	2.447	—	0.282	2.293
86	carbon steel	1.0493	2.664	2.215	0.032	12.114[3]
109-Phase 1	Al 1100	5.9015	4.172	1.920	0.276	4.922
109-Phase 2	LEU	2.9502	2.497	—	0.276	2.285
109-Phase 2	carbon steel	0.14	1.054	0.777	0.032	1.755

(1) The experimental numbering sequence corresponds to data recording practices
(2) The Al 1100 coupon surface area was calculated for a 10 mm immersion depth; the surface area for all others coupons was calculated for full immersion
(3) Carbon steel coupon had 1/16 inch hole near the top so the surface area was adjusted for this effect

2.2.2 Dissolving System

The vessel and offgas condenser used to perform the LEU flowsheet demonstration was fabricated from borosilicate glass by the SRNL Glass Shop. The dissolving vessel was made from a 300-mL round-bottom flask. Penetrations were added for a condenser, Hg addition (using a syringe pump), thermocouple, and gas purge. The bottom of the flask was flattened slightly to facilitate heating and agitation using a hot plate/stirrer with a magnetic stir bar. During the dissolutions, coupons were charged to the dissolver in a glass basket suspended by a glass rod which was held in place by a compression fitting. The compression fitting allowed adjustment of the basket height during dissolution. The solution temperature was controlled using an external thermocouple monitored by the hot plate. Offgas exiting the dissolving vessel was sampled for analysis by mass spectrometry using a sample line connected to a port just above the condenser (which was used in Experiments 80 and 86); although, this capability was not used for Experiment 109. A manometer, also connected to the offgas sample port, acts as a pressure relief device and provides a measurement of the pressure in the system. The offgas leaving the condenser subsequently passes through a cell containing a Raman probe and terminates in a bubbler (i.e., beaker containing 700 mL or 3.5 in of deionized water). The bubbler prevents air in-leakage from the vent side of the system. The Raman spectrometer was used to measure non-condensable gases such as H_2, N_2, O_2, Ar, NO, N_2O and NO_2 in real time during the experiment. A photograph of the equipment is shown in Figure 2-1.

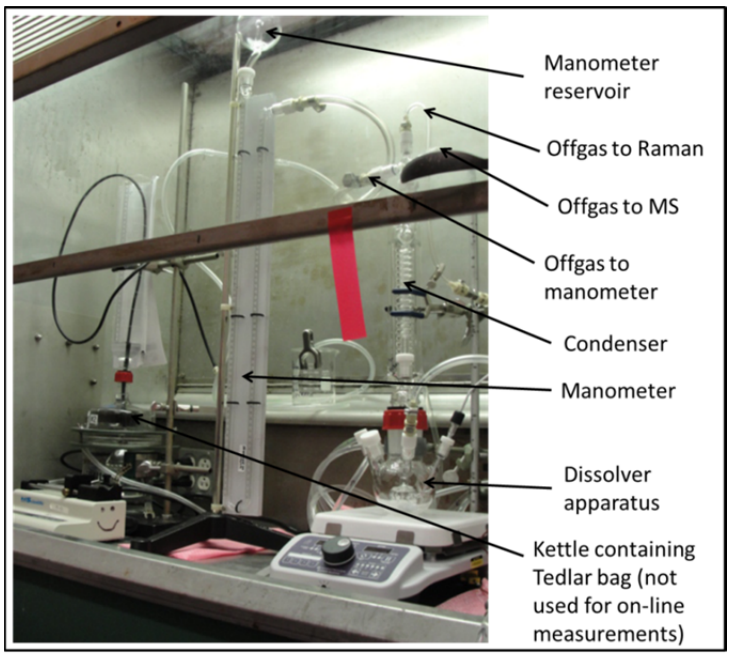

Figure 2-1. Dissolver Setup with Online MS and Raman Offgas Analyzers

2.2.2.1 Monitor Mass Spectrometer

The MS used during the dissolution experiments was a Monitor Instruments LAB 3000 Cycloidal MS. The Monitor MS samples a portion of the non-condensable offgas stream using vacuum and provides the volume percent of the gases in the sample based on calibration gas standards. The Monitor MS was calibrated using the gases listed in Table 2-3. The MS is controlled by a computer using Monitor v6.00 software.

To calculate offgas generation rates, an Ar tracer gas was metered into the system through a flow controller at a set rate (10 cm^3/min @ 70 °F, 1 atm). The total offgas rate was then calculated by dividing the set input rate by the measured Ar concentration in the offgas.

Table 2-3. Calibration Gases for MS and Raman Analyzers

Supplier	Gas	Ar	N_2	N_2O	NO_2	NO	O_2	H_2
—	—	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Air Liquide	20% N_2O-80% Ar	80.00	—	20.00	—	—	—	—
Liquid Technology	5% NO_2-20% O_2-75% Ar	74.89	—	—	4.98	—	20.13	—
Air Liquide	20% NO-80% Ar	80.00	—	—	—	20.00	—	—
Air Liquide	5% N_2-10% H_2-85% Ar	85.00	5.00	—	—	—	—	10.00
SRNL	Ar(1)	99.9	—	—	—	—	—	—
SRNL	N_2(1)	—	99.9	—	—	—	—	—
SRNL	Air(1)	0.94	78.03	—	—	—	20.99	—

(1) purity not measured; supplied from SRNL facility gases

Calibration of the MS is discussed in Appendix A.

2.2.2.2 Raman Spectrometer

The Raman spectrometer non-intrusively analyzes the offgas through a quartz window using the excitation of a laser passing through a fixed portion of the offgas stream. The Raman scattering technique identifies and measures the concentration of gases in the offgas stream. The Raman spectrometer was calibrated using the standard gases shown in Table 2-3. The Raman spectrometer measures the concentrations of the offgas species approximately every 12-13 seconds. Since the Raman spectrometer directly measures the concentrations in the offgas stream, there is zero dead time between the offgas concentration measurement and the reading, other than the analysis time of 12-13 seconds. The Raman spectrometer was controlled by and data was logged using a computer running EZRamanReader v8.3.9 software and an Excel spreadsheet.

To calculate offgas generation rates, a CO_2 tracer gas was metered into the system through a flow controller at a set rate (20 cm^3/min @ 70 °F, 1 atm). The total offgas rate was then calculated by dividing the set input rate by the measured CO_2 concentration in the offgas.

Calibration of the Raman spectrometer and treatment of the data is discussed in Appendix D.

2.2.3 Dissolution Experiments

Prior to performing a dissolution experiment, the dissolving system was checked for leaks by connecting a Tedlar® bag inside a glass kettle filled with water (Figure 2-1.) to the dissolver and adding sufficient Ar, N_2, or CO_2 to the bag to generate a column of water 18-28 cm tall. The Tedlar® bag system was then closed and monitored for any observable decrease in the water column height over 2-3 min. After the system integrity was confirmed, the experiment was started.

To perform the dissolutions, a metal coupon was initially placed in the perforated glass basket or tied to a glass rod. For Experiment 80, the basket containing a sample of an LEU ingot was lowered completely into the solution at boiling. For Experiment 86 a carbon steel can coupon was tied to a glass rod and lowered into the solution at room temperature. For Experiment 109-Phase 1, the basket containing an Al 1100 coupon was lowered to a depth of 10 mm at room temperature and the solution was then heated to boiling. Chilled water (at 3 °C) was circulated through the condenser during the dissolutions to remove water vapor from the offgas stream before the gas flowed through the Raman cell. For the Al 1100 coupon dissolution, once the solution reached boiling, there was a hold time of 45 minutes before starting the Hg addition to reduce the initial offgas surge. The initial volume of HNO_3 and the volume of the Hg solution added (Table 2-4) were based on the mass of the Al 1100 coupon and the target Al and Hg concentrations.

Table 2-4. Dissolving Solution Volume and Composition

Exp. No.	Initial Volume	Hg Solution Volume	Target Hg Concentration	Target Al Concentration
—	(mL)	(mL)	(M)	(M)
80	150	0	0	0
86	150	0	0	0
109-Phase 1	134	1.61	0.002	1.6
109-Phase 2	137	0	0.002	1.6

In Experiment 109, an estimate of the amount of HNO_3 consumed during the dissolution of Al, U, and Fe metals was required to allow the adjustment of the acid concentration prior to the dissolution of samples of a carbon steel can and a LEU ingot in Phase 2 of the experiment. The stoichiometry of Hg-catalyzed Al dissolution in HNO_3 has been discussed in many references such as Almond et al.[16] where the general overall reaction of Al with HNO_3 is given by equation 5.

$$Al_{(s)} + 3.75\ HNO_3 \rightarrow Al(NO_3)_3 + 0.225\ NO_{(g)} + 0.15\ N_2O_{(g)} + 0.1125\ N_{2(g)} + 1.875\ H_2O_{(g)} \quad (5)$$

Based on equation 5, 3.75 moles of HNO_3 are needed to dissolve 1 mole of Al.

To estimate the amount of HNO_3 required to dissolve the carbon steel coupon, offgas composition data from the dissolution of a carbon steel can coupon were examined and the reactions given by equations 6-8 were assumed.

$$Fe_{(s)} + 6\ HNO_3 \rightarrow Fe(NO_3)_3 + 3\ NO_{2(g)} + 3\ H_2O \quad (6)$$

$$2\ Fe_{(s)} + 8\ HNO_3 \rightarrow 2\ Fe(NO_3)_3 + 2\ NO_{(g)} + 4\ H_2O \quad (7)$$

$$2\ Fe_{(s)} + 8\ HNO_3 \rightarrow 2\ Fe(NO_3)_3 + N_{2(g)} + O_{2(g)} + 4\ H_2O \quad (8)$$

Based on the steady state offgas composition from the carbon steel can coupon dissolved in Experiment 86, a weighted average of the three reactions above (Equation 6-8) was used to estimate the overall consumption of HNO_3 per mole of Fe as shown in Table 2-5. Based on these reactions, 4.12 moles of HNO_3 are required to dissolve 1 mole of Fe.

Table 2-5. Overall HNO_3 Consumption per mole Fe

Gas	Gas Produced on Ar Basis (vol %)	Gas Produced on Ar Free Basis (vol %)	Potential Reaction	gmole HNO_3 used/gmole Fe	weighted gmole HNO_3/gmole Fe
NO_2	0.4	6%	Eqn 6	6	0.36
NO	5.6	85%	Eqn 7	4	3.39
N_2	0.6	9%	Eqn 8	4	0.36
totals	6.6	100%			4.12

The amount of HNO_3 consumed during the dissolution of U metal was based on the theoretical requirement for compete oxidation of the U and absorption of the nitrogen oxides in the dissolving solution and subsequent oxidation back to HNO_3 (equation 9).

$$U_{(s)} + 2\ HNO_3 + 3/2\ O_2 \rightarrow UO_2(NO_3)_2 + H_2O_{(g)} \quad (9)$$

Based on the theoretical amount of HNO_3 needed to dissolve the Al, Fe, and U, projections of the concentrations of the various metals and HNO_3 were made for Experiment 109 (Table 2-6). In Phase 1 of the experiment, the Al 1100 coupon was dissolved using 0.002 M Hg in 134 mL of 7 M HNO_3. The final volume in Phase 1 was 128 mL due to evaporation losses from solution boiling. After Phase 1 was complete, aliquots of a 0.45 M HNO_3 solution containing 308 g ^{238}U/L and 15.8 M HNO_3 were added to the solution to bring the HNO_3 concentration up to about 1.4 M and the U concentration up to 4.5 g/L. A 7 mL aliquot of the 15.8 M HNO_3 was added based on the theoretical amount of HNO_3 required to dissolve the Fe and LEU samples during Phase 2 of the experiment (Table 2-6). The final volume after Phase 2 was complete was 132 mL due to evaporation losses which should result in final concentrations of approximately 26.8 g U/L, 1.66 M Al, 1.1 g Fe/L, and 1.17 M HNO_3.

Table 2-6. HNO_3 Concentration Estimates for Metal Consumption and Component Addition

Exp 109 Step	Component	Initial Mass (g)	Initial Amount (mole)	mole HNO_3 used/mole Metal	mole HNO_3 used	Initial HNO_3 (mole)	Final HNO_3[(1)] (mole)	Initial Volume (mL)	Final Volume (mL)	Final HNO_3 (M)
Phase 1	Al	5.9015	0.219	3.75	0.820	0.885	0.065	134	126.4	0.52
	Hg[(2)]	0.0546	2.72E-4	0	0	0.012	0.077	1.61	128.0	0.60
Trim	U[(2)]	0.00857	3.60E-5	0	0	0.001	0.078	1.9	129.9	0.60
	HNO_3	---	0.111	0	0	0.111	0.189	7	136.9	1.38
Phase 2	Fe	0.14	2.51E-3	4.12	0.01	0.189	0.179	136.9	136.9	1.30
	LEU	2.9502	1.24E-2	2.0	0.025	0.179	0.154	136.9	132.0	1.17

(1) Values are cumulative based on the addition or consumption of HNO_3
(2) Solutions containing Hg and U components

During the experiments, samples of the final dissolving solutions were collected for analysis. Samples were submitted to SRNL Analytical Development to measure the HNO_3 (total and free acid) and metals concentrations in reagents and in final dissolving solutions. The free acid and metals concentrations were determined by titration, inductively-coupled plasma emission spectroscopy (ICPES) or inductively-coupled plasma mass spectroscopy (ICPMS), respectively. The analyses were used as checks on the concentrations since the initial and final volumes of the dissolver solutions were measured as well as the mass of Al added to each solution.

2.3 Dissolution Experiments to Evaluate LEU Reactivity

To ensure that the concentrations of Zr in the LEU ingots are well below levels at which the material would exhibit any violent exothermic behavior, dissolution experiments were performed by heating 2-4 g samples in an open glass beaker containing 7 M HNO_3. The beaker was heated to approximately 70 °C using a hot plate/stirrer. The contents of the beaker were mixed at 200 RPM using a magnetic stir bar. A watch glass containing water was placed on top of the beaker to limit the evaporation of the dissolving solution. The dissolutions took about 4 h to complete. The sample was observed throughout the experiment for violent exothermic behavior and to determine when the LEU dissolution was complete.

Although the LEU sample appeared to dissolve (i.e., the solution contained no visible solids), the analyzed concentration of Zr was less than reported by INL.[2] To address this issue, additional samples of the LEU were dissolved using a 7 M HNO_3 solution containing 0.2 M KF assuming that insoluble Zr was present in the solutions which was not visible to the naked eye. These experiments were performed in the same manner, except a Teflon™ beaker was used for the dissolutions to prevent corrosion of the glass by the fluoride-containing solution. The solutions from both types of experiments were analyzed by ICPMS.

2.4 Chloride Contamination

When the dendritic U product is removed from the INL electrorefiner, the material is transferred to the cathode processor where the U and chloride salts are melted and the salts removed by distillation. The presence of chloride salts occluded within the LEU ingot or on the surface is a corrosion concern for the H-Canyon dissolvers and downstream processing operations. Although the chloride salts associated with the samples of the LEU received from INL may not be a good measure of the chloride salts associated with the ingots (due to the sample casting operation), the dissolving solution from two of the LEU samples were analyzed for chloride by ion chromatography.

2.5 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in manual E7, 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.

3.0 Results and Discussion

3.1 Dissolution Flowsheet for LEU Ingots

Samples of LEU ingots from the pyroprocessing of the EBR-II U-5Fs fuel at the INL were dissolved in experiments simulating two potential H-Canyon processing scenarios. In Experiment 80, a subsample from INL sample SADZA18 was dissolved using 7 M HNO_3 to simulate the dissolution of the LEU ingots in an H-Canyon dissolver prior to dissolving any SNF. Although, the preferred processing scenario was changed to the dissolution of LEU ingots following the batch of SNF, data for this experiment are reported to illustrate other aspects of the dissolution flowsheet. Experiment 109 was performed to demonstrate the dissolution of a subsample of INL sample SADZA29 in a 1.4 M HNO_3 solution containing 1.6 M Al and 4.3 g U/L. These concentrations are representative of the solution composition following the dissolution of a batch of SNF with the HNO_3 concentration adjusted (upward) to allow the dissolution of 75 kg of LEU. Experiment 86 was performed to evaluate the H_2 generation when a sample of a carbon steel can (representative of the ones proposed for shipment of the LEU from INL to SRS) is dissolved in 7 M HNO_3.

3.1.1 Rate of Dissolution

The total offgas generation rate curves (which illustrate the extent of dissolution) for these experiments are plotted as a function of time in Figure 3-1. Time zero for the dissolution of the LEU and carbon steel can samples in 7 M HNO_3 (Experiment 80 and 86, respectively) represents the time when the offgas generation started. For Experiment 109-Phase 1, time zero represents the start of the Hg addition. The LEU material takes much longer to dissolve than the Al 1100 alloy. The LEU material in Experiment 109-Phase 2 dissolved in about 16,500 s (275 min) and in Experiment 109-Phase 1, the Al 1100 alloy dissolved in 2,611 s (43.5 min). In Experiment 80, the average LEU dissolution rate was 5.6 mg/min/cm^{2}or 13 mg/min when the dissolving solution initially contained 7 M HNO_3. In Experiment 109-Phase 2, the average LEU dissolution rate was 4.7 mg/min/cm^2 or 11 mg/min when a 1.4 M HNO_3 solution containing 1.6 M Al and 4.3 g U/L was used to dissolve the LEU metal. For comparison, in Experiment 109-Phase 1, the average dissolution rate of the Al 1100 alloy was approximately 27 mg/min/cm^2 or 135 mg/min starting with a 7 M HNO_3 solution containing 0.002 M Hg. The dissolution rate of the carbon steel can based on Experiment 86 was approximately 68 mg/min/cm^2 or 828 mg/min. Given the lower acidity and higher Al concentration used in Experiment 109-Phase 2 compared to solution used in Experiment 80, the dissolution times are reasonably consistent with the lower acidity and the presence of the Al only slowing down the LEU dissolution by approximately 20%.

The instantaneous dissolution rate of a sample of an LEU ingot was also measured by periodically removing the sample from the dissolving solution and measuring the mass and physical dimensions (i.e., diameter and length) and then returning the sample to the boiling solution.

Table 3-1 shows the masses and dimensions of a subsample from INL sample SADAZ17 at various time intervals. The measured dissolution rate was obtained as the slope of the regression line from a plot of the mass-to-surface area ratio versus time (Figure 3-2). Based on this experiment, the instantaneous dissolution rate for the LEU metal sample was 12 mg/min/cm^2.

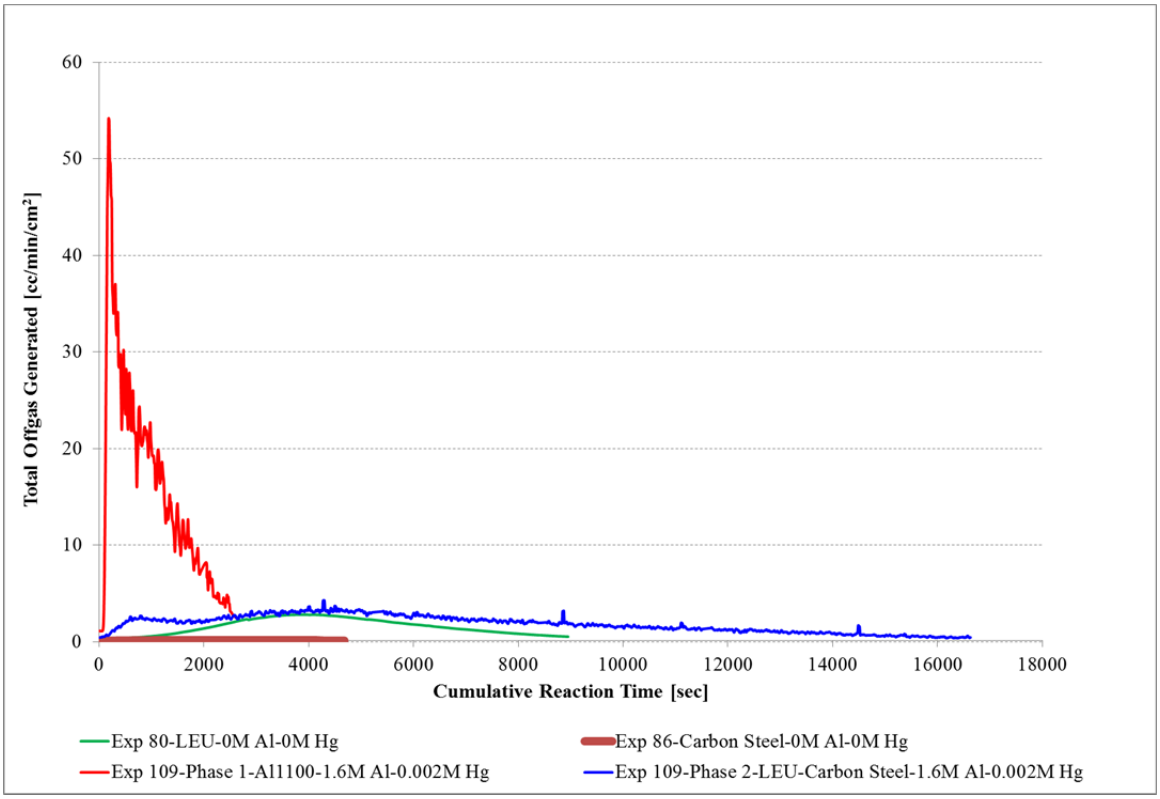

Figure 3-1. Offgas Generation Rates for LEU, Carbon Steel, and Al 1100 Alloy Samples

Table 3-1. Dissolution of EBR-II LEU Metal in Boiling HNO_3

Time (min)	Mass (g)	Diameter (mm)	Length (mm)	Surface Area (SA) (cm^2)	Mass/SA (mg/cm^2)
0.0	3.1505	2.86	26.34	2.495	1263
22.3	2.9547	2.81	26.05	2.424	1219
42.3	1.9656	2.35	25.9	1.999	983
52.0	1.5049	2.13	25.71	1.792	840
62.0	1.1110	1.76	24.82	1.421	782
72.1	0.7943	1.54	24.87	1.240	640
82.1	0.5409	1.27	24.56	1.005	538
92.2	0.3355	1.01	24.5	0.793	423
102.3	0.1717	0.8	24.15	0.617	278
112.4	0.0540	0.47	24.13	0.360	150

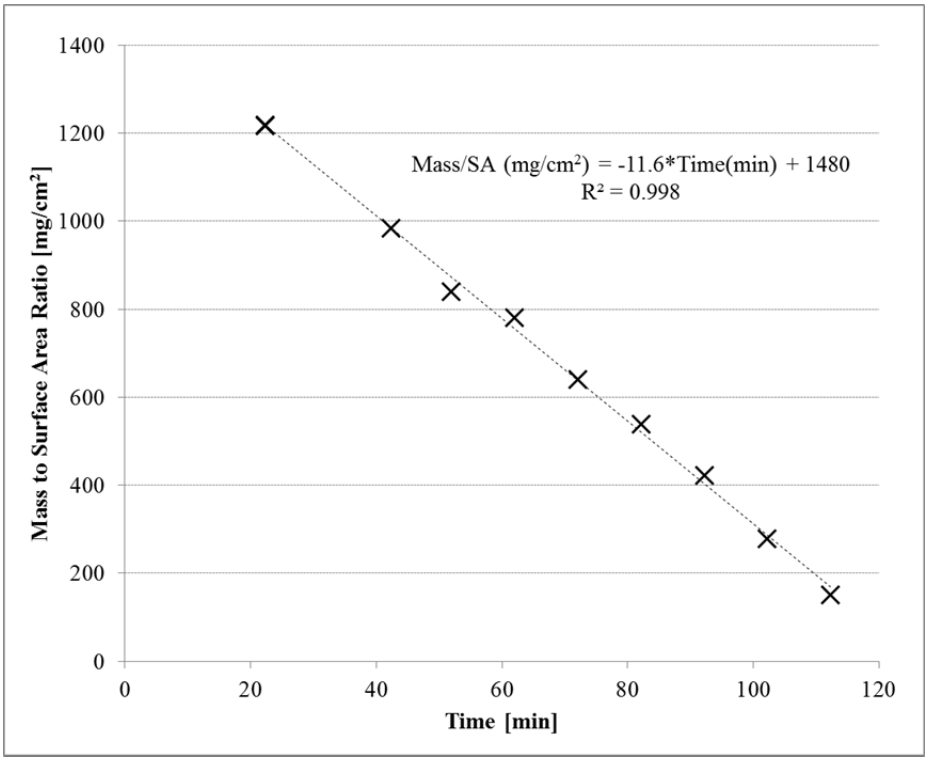

Figure 3-2. Mass-to-Surface Area Ratio versus Time for Dissolution for LEU Sample

3.1.2 Offgas Characterization

The dissolution of SNF prior to dissolving LEU ingots from INL must be performed using either the MTR or HFIR flowsheet developed specifically for these fuels.[13,14] The conditions specified by the flowsheet and the constraints on the number of L-Bundles or cores which can be charged to an H-Canyon dissolver as a function of the Al concentration ensure that the predicted H_2 concentration in the offgas from dissolution is less than 60% of the H_2 LFL at 200 °C.[12] The H_2 generation rate from either the dissolution of the LEU metal or the carbon steel can is inconsequential. Figure 3-3 shows the H_2 generation rates during the dissolution of samples from an Al 1100 alloy (Experiment 109-Phase 1), a LEU ingot (Experiment 80), a carbon steel can (Experiment 86), and a LEU ingot plus a carbon steel can (Experiment 109-Phase 2). In Experiments 80 and 86, the samples from a LEU ingot and a carbon steel can, respectively, were dissolved in pure 7 M HNO_3. Samples of the two materials were dissolved at the same time in Experiment 109-Phase 2 using a 1.4 M HNO_3 solution containing 1.6 M Al, which models the dissolution of the LEU ingots in an H-Canyon dissolver after a batch of MTR or HFIR fuel. Figure 3-3 shows that the H_2 generation rate from the dissolution of a sample of an LEU ingot is very low and the generation rate from the dissolution of a sample of a carbon steel can is essentially zero; therefore, the dissolution of neither material generates an offgas which is a flammability concern. Dissolution and offgas measurement experiments have been performed to evaluate the behavior of nylon bags (proposed for the primary containment of the LEU ingots) in other flowsheets developed for H-Canyon. Nylon bags dissolve in HNO_3 and do not contribute any significant offgas to the dissolution process.[15]

3.1.3 Solution Analyses from the Flowsheet Demonstration

The predicted Al molarity following the dissolution of the Al 1100 alloy coupon in Experiment 109-Phase 1 was 1.66 M and the measured Al molarity was 1.68 M which shows that the Al dissolution was well tracked. The predicted U concentration following completion of Phase 2 of the experiment was 26.8 g/L while the measured value was 25.1 g/L which shows that the masses and volumes were well understood. The predicted free acid at the end of the LEU dissolution was 1.16 M and the predicted total

acid was 6.37 M while the measured free acid was 1.1 M and the measured total acid was 6.45 M, which indicate that the assumptions for the consumption of HNO_3 were accurate.

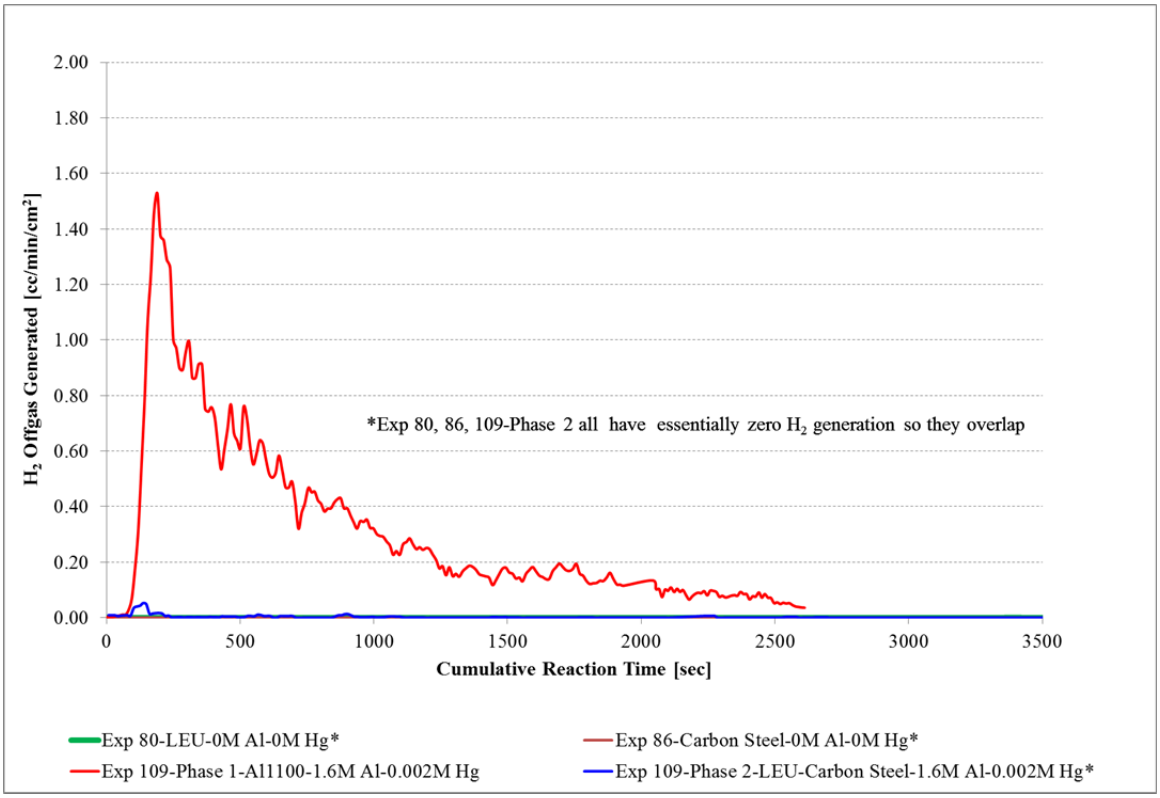

Figure 3-3. H_2 Generation Rates for LEU, Carbon Steel, and Al 1100 Alloy Samples

3.2 Potential Explosive Behavior of U-Zr Alloys during H-Canyon Dissolution

A potential concern during the HNO_3 dissolution of U metal containing Zr is the explosive behavior that has been reported for alloys of this material.[7,8,9] Larsen et al. concluded that U-Zr alloys with 1-50 wt % Zr will contain some amount of the finely divided epsilon phase which can result in violent dissolution behavior.[9] Concentrations below 1 wt % (10,000 µg/g U) were not reported to exhibit exothermic behavior. No violent exothermic behavior was observed during the dissolution of any pieces of the LEU samples from the INL ingots. To benchmark the concentration of Zr in the samples received from INL (SADZA17, SADZA18, SADZA28, and SADZA29), the concentration of Zr was measured in a number of the dissolving solutions. In the first series of experiments (Experiments 79-81), samples of the solution following dissolution of the metal in a pure HNO_3 solution were analyzed by ICPMS. Although the LEU sample appeared to dissolve (i.e., no visible solids were observed), the analyzed concentrations of Zr were 43-56% lower than reported by INL (Table 3-2). To address this issue, additional samples of the LEU were dissolved (Experiments 102-104) using a 7 M HNO_3 solution containing 0.2 M KF and analyzed by ICPMS assuming that insoluble Zr was present in the previous solutions, but could not be seen. The Zr analyses from the second series of dissolution experiments were consistent (within analytical uncertainty) with the values reported by INL (Table 3-2). These low concentrations of Zr in the LEU ingots are not a concern for the dissolution of the material in an H-Canyon dissolver based on the literature (Larsen et al.[9]) and the laboratory experiments. Complete dissolution of the Zr in an LEU ingot is not required during dissolution in an H-Canyon dissolver; therefore, no fluoride is required in the dissolving solution to fully solubilize Zr. Undissolved solids should be easily removed by the Head End centrifuge using the standard gelatin strike process.

Table 3-2. Zr Concentration in LEU Samples

Exp No.	INL Sample Designation	Sample Mass (g)	Solution Volume (mL)	Zr Conc.(1) (µg/L)	Zr Conc. (µg/g U)	Zr Conc. INL(2) (µg/g U)
79	SADZA17	3.1505	108	2,420	83	146
80	SADZA18	2.8434	147	1,430	74	146
81	SADZA17	3.2187	135	1,520	64	146
102	SADZA17	2.7821	94	4,690	158	146
103	SADZA28	3.6235	110	31,000	941	1008
104	SADZA29	4.4391	146	28,900	951	1008

(1) Analysis uncertainty = ±10%
(2) References for INL analytical data (17, 18, 19, 20, 21, and 22)

3.3 Potential for Chloride Corrosion

The solutions from the dissolution of samples of the LEU ingots in Experiments 80 and 104 were analyzed for chloride by ion chromatography. Table 3-3 shows that the concentration of chloride in both dissolving solutions was less than the detection limit (100 µg/mL). The upper limit on the concentrations of chloride associated with the LEU samples are also provided in the table. Monitoring the chloride concentration in the H-Canyon dissolver used to process the LEU ingots is recommended since the data from the sample dissolutions could only provide an upper bound on the estimated concentration in the solution. In addition, the chloride salts associated with the samples of the LEU received from INL may not be a good measure of the chloride salts associated with the ingots due to the sample casting operation.

Table 3-3. Chloride Analyses by Ion Chromatography

Exp No.	INL Sample Designation	Sample Mass (g)	Solution Volume (mL)	Chloride Conc. (µg/mL)	Chloride Conc. (µg/g U)
80	SADZA18	2.8434	147	< 100	< 5200
104	SADZA29	4.4391	146	< 100	< 3300

3.4 Downstream Processing of Dissolved SNF and LEU Ingots

Following dissolution of a MTR or HFIR fuel batch and LEU ingots from INL, the solution would be processed through Head End and the 1st and 2nd Cycles of solvent extraction to recover the enriched U for subsequent down-blending for use as commercial reactor fuel. No issues associated with the processing of the enriched U solutions through Head End and solvent extraction are anticipated. The combined solution from the dissolution of the SNF and LEU ingots will contain undissolved solids such as transition metal fission products (e.g., Zr, Mo, Ru, Tc, Pd, and Ag), Si (as SiO_2) which is present in the Al alloys and produced from the transmutation of Al during fuel irradiation, and likely a small amount of undissolved or precipitated Zr from the LEU ingot. These solids should be easily removed by the Head End centrifuge using the standard gelatin strike process. Once the solution is clarified, purification by solvent extraction should proceed in the same manner as in previous campaigns. High and low activity waste generated from the processing will be neutralized and prepared for disposal using existing SRS facilities. No issues are anticipated in this process.

4.0 Conclusions

A dissolution flowsheet for LEU ingots generated at the INL from the pyroprocessing of EBR-II U-5Fs fuel was demonstrated on the laboratory scale. The flowsheet allows the dissolution of a SNF batch in an H-Canyon dissolver using the existing MTR or HFIR fuel dissolution flowsheet,[13,14] followed by the dissolution of nominally 75 kg of LEU recovered from the EBR-II fuel in the 6.4D dissolver and 45 kg of

the LEU in the 6.1D dissolver. It may be necessary to add additional HNO_3 to the dissolver prior to dissolving the LEU to ensure the final acidity is greater than 0.5 M. In the demonstration experiment, the HNO_3 concentration was increased to nominally 1.4 M prior to dissolving samples of the LEU and a carbon steel can. In the demonstration experiment, the rate of dissolution of the LEU metal was significantly slower than the dissolution rate of an Al 1100 alloy used to model the dissolution of SNF (4.7 mg/min/cm^2 versus 27 mg/min/cm^2). The H_2 generation rate from the dissolution of samples of the LEU metal and a carbon steel can were inconsequential; therefore, the dissolution of the LEU ingots has no significant impact on the generation of H_2.

The LEU samples received from the INL contained up to approximately 1000 µg Zr/g U. A potential concern during the HNO_3 dissolution of U metal containing Zr is the explosive behavior that has been reported for alloys of these materials; however, concentrations below 10,000 µg Zr/g U have not resulted in violent dissolution behavior. No violent exothermic behavior was observed during the dissolution of any pieces of the LEU samples from the INL ingots. The presence of chloride salts from the INL electrorefiner which are associated with the LEU ingots are a potential H-Canyon corrosion concern. The concentration of chloride in solutions from the dissolution of samples of the LEU were less than the detection limit (100 µg/mL); however, the chloride salts associated with the LEU samples may not be a good measure of the chloride salts associated with the ingots due to the sample casting operation.

5.0 Flowsheet Recommendations

The existing MTR or HFIR flowsheet shall be used for the dissolution of SNF prior to the dissolution of the LEU ingots from INL. Applicable constraints are given in the flowsheet documentation.[13,14]

Additional HNO_3 shall be added to the H-Canyon dissolver prior to charging the LEU ingots (if necessary) to ensure that the final concentration following the dissolution is greater than 0.5 M. A dissolver air sparge/purge flow rate of at least 40 SCFM shall be maintained during the dissolution. Monitoring the chloride concentration in the dissolver during the LEU dissolution campaign is recommended due to the potential for the ingots to be associated with chloride salts from the INL electrorefiner. The dissolution rate per unit surface area of the LEU metal is approximately a factor of five slower than the dissolution rate of Al 1100 alloy; therefore, the dissolver cycle time for the LEU ingots will likely increase proportionally. Based on the MTR and HFIR flowsheets, the estimated dissolution time is 120 to 240 h.

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Appendix A. Monitor MS Calibration and Sampling Method

The Monitor MS was calibrated using a set of calibration gases as shown in Table 2-3 before the start of each dissolution experiment. The calibration gases were then sampled back through the MS to check the calibration. If the calibration checks were off for particular gases, the MS calibration matrix was adjusted for those gases after the run. For the Al dissolution performed in Experiments 80 and 86, the calibration checks with the adjusted MS calibration matrix are shown in Table A-1. The calibration check tells us if the calibration was successful and provides an indication of the variance of the measurements since the calibration gas is read for several samples. Due to rounding to the nearest hundredth, the numbers in the table may not sum to 100 but all the decimals were carried in the calculations performed in this report.

Table A-1. Pre-run Check of Calibration Gases for Al Dissolution Experiments 80 & 86

Gas Description	H_2 (%)	N_2 (%)	NO (%)	O_2 (%)	Ar (%)	N_2O (%)	NO_2 (%)
20% N_2O-80% Ar	0.04	0.00	0.00	0.00	79.45	20.07	0.44
	0.04	0.00	0.00	0.00	79.38	20.24	0.34
	0.04	0.00	0.00	0.00	79.26	20.36	0.35
	0.04	0.00	0.00	0.00	79.25	20.35	0.36
	0.02	0.00	0.03	0.00	79.34	20.38	0.23
	0.02	0.00	0.03	0.00	79.38	20.32	0.25
	0.02	0.00	0.03	0.00	79.37	20.35	0.23
	0.02	0.00	0.03	0.00	79.27	20.45	0.23
4.98% NO_2-20.13% O_2-74.89% Ar	0.04	0.83	0.00	19.94	74.17	0.08	4.94
	0.04	0.83	0.00	19.94	74.11	0.09	4.99
	0.03	0.82	0.00	19.93	74.12	0.08	5.02
	0.04	0.78	0.00	19.93	74.06	0.08	5.11
	0.02	0.28	0.02	20.00	74.79	0.02	4.87
	0.02	0.28	0.02	19.99	74.69	0.02	4.98
	0.02	0.28	0.02	19.99	74.69	0.02	4.98
	0.02	0.28	0.01	19.98	74.67	0.02	5.02
20% NO-80% Ar	0.04	0.08	20.07	0.00	79.63	0.07	0.11
	0.04	0.07	20.08	0.00	79.65	0.07	0.08
	0.04	0.07	20.09	0.00	79.67	0.07	0.06
	0.04	0.07	20.10	0.00	79.68	0.07	0.05
	0.03	0.12	19.69	0.00	80.04	0.05	0.07
	0.02	0.12	19.70	0.00	80.07	0.05	0.05
	0.02	0.12	19.70	0.00	80.07	0.05	0.05
	0.03	0.12	19.70	0.00	80.05	0.05	0.06
5% N_2-10% H_2-85% Ar	10.02	5.02	0.00	0.00	84.91	0.03	0.03
	10.03	5.01	0.00	0.00	84.93	0.02	0.00
	10.03	5.00	0.00	0.00	84.92	0.02	0.03
	10.05	4.98	0.00	0.00	84.91	0.02	0.03
	9.96	5.02	0.00	0.00	84.99	0.00	0.02
	9.97	5.01	0.00	0.00	84.99	0.00	0.02
	9.97	4.99	0.00	0.00	85.02	0.00	0.01
	9.96	4.97	0.00	0.00	85.05	0.00	0.01

Gas Description	H_2 (%)	N_2 (%)	NO (%)	O_2 (%)	Ar (%)	N_2O (%)	NO_2 (%)
100% Ar	0.04	0.01	0.00	0.00	99.69	0.09	0.18
	0.03	0.02	0.00	0.00	99.92	0.03	0.00
	0.04	0.02	0.00	0.00	99.90	0.03	0.01
	0.03	0.02	0.00	0.00	99.92	0.03	0.00
	0.02	0.05	0.00	0.00	99.93	0.00	0.00
	0.02	0.03	0.00	0.00	99.94	0.00	0.01
	0.02	0.03	0.00	0.00	99.95	0.01	0.00
	0.02	0.02	0.00	0.00	99.94	0.00	0.01
100% N_2	0.04	99.89	0.03	0.00	0.00	0.00	0.04
	0.04	99.95	0.01	0.00	0.00	0.00	0.00
	0.04	99.95	0.01	0.00	0.00	0.00	0.00
	0.04	99.95	0.01	0.00	0.00	0.00	0.00
	0.03	97.85	0.00	2.11	0.00	0.00	0.01
	0.03	97.94	0.00	2.03	0.00	0.00	0.00
	0.03	97.96	0.00	1.98	0.00	0.00	0.03
	0.02	98.05	0.00	1.93	0.00	0.00	0.00
Air (78.0% N_2-21.0% O_2-0.9% Ar)	0.04	76.03	0.00	23.28	0.63	0.00	0.02
	0.05	76.03	0.00	23.27	0.63	0.00	0.02
	0.04	76.03	0.00	23.30	0.62	0.00	0.00
	0.04	75.99	0.00	23.33	0.62	0.00	0.01
	0.04	74.89	0.00	24.42	0.63	0.00	0.02
	0.03	74.88	0.00	24.44	0.63	0.00	0.01
	0.04	74.89	0.00	24.44	0.63	0.00	0.01
	0.03	74.83	0.00	24.49	0.63	0.00	0.01

To estimate the variability of the MS concentration measurements, the pre-run check values in Table A-1 were compared to the standard or calibrated values across Experiment 80 and 86. The standard deviations of the measured concentrations with respect to the known calibrated concentrations for the data were calculated. The standard deviations were then doubled to get a measure of the variability in the MS measurements. Table A-2 shows the standard deviation of the measured concentrations with respect to the calibrated values. For the H_2, N_2, Ar, NO, NO_2, and N_2O gases, the 2σ value or twice the standard deviation is <1 vol %. The 2σ value for O_2 gases is < 2 vol %.

Table A-2. Standard Deviation of MS Concentrations with Respect to Calibrated Values

Gas	Standard Deviation (σ)	2*Standard Deviation (2σ)
	(vol %)	(vol %)
H_2	0.035	0.07
N_2	0.02	0.04
NO	0.22	0.44
O_2	0.56	1.12
Ar	0.13	0.26
N_2O	0.33	0.66
NO_2	0.07	0.14

Once the calibration is complete, the system is purged with 100% Ar while the Monitor MS is sampling the system offgas. By checking the calibration gases after calibration and purging the system with 100% Ar, a set of baseline or zero values for the offgas concentrations can be collected and analyzed. The baseline values for Experiment 80 and 86 are shown in Table A-3. These baseline values represent zero or 100% concentrations within the accuracy of the Monitor MS. In other words, the raw N_2, N_2O, NO_2, NO, O_2, and H_2 MS readings are re-baselined by subtracting off the average baseline values like shown in Table A-3 through Table A-4. The raw Ar MS reading is re-baselined to 100% by dividing by the average baseline value shown in Table A-3 while limiting the maximum to 100%. The re-baselined values are then re-normalized to ensure that the sum of the re-baselined values is 100% because the MS is setup so that all the measured gases sum to 100%. The total offgas flow is then calculated by dividing the Ar tracer flow coming into the system by the re-baselined normalized Ar concentration as shown in Table A-5. The offgas flow rates and re-baselined normalized MS offgas concentrations for Experiment 80 and 86 are shown in Appendices B and C, respectively.

Table A-3. Monitor MS Baseline Offgas Concentrations for Experiment 80

Sample	H_2	N_2	NO	O_2	Ar	N_2O	NO_2
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1	0.04	0.11	0.00	0.00	99.79	0.04	0.02
2	0.04	0.11	0.00	0.00	99.77	0.04	0.04
3	0.04	0.11	0.00	0.00	99.79	0.04	0.02
4	0.04	0.11	0.00	0.00	99.79	0.04	0.02
5	0.04	0.11	0.00	0.00	99.79	0.04	0.02
6	0.04	0.11	0.00	0.00	99.79	0.04	0.03
7	0.04	0.11	0.00	0.00	99.80	0.04	0.01
8	0.04	0.11	0.00	0.00	99.78	0.04	0.03
9	0.04	0.11	0.00	0.00	99.79	0.04	0.02
10	0.04	0.11	0.00	0.00	99.77	0.04	0.04
11	0.04	0.11	0.00	0.00	99.80	0.04	0.01
12	0.04	0.11	0.00	0.00	99.76	0.04	0.05
13	0.04	0.11	0.00	0.00	99.78	0.04	0.03
14	0.04	0.11	0.00	0.00	99.79	0.04	0.03
15	0.04	0.11	0.00	0.00	99.80	0.04	0.00
16	0.04	0.11	0.00	0.00	99.81	0.04	0.00
Average	0.04	0.11	0.00	0.00	99.79	0.04	0.02
Re-baseline	0	0	0	0	100	0	0

Table A-4. Monitor MS Baseline Offgas Concentrations for Experiment 86

Sample	H_2	N_2	NO	O_2	Ar	N_2O	NO_2
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1	0.06	0.23	0.00	0.00	99.68	0.02	0.01
2	0.06	0.21	0.00	0.00	99.71	0.02	0.01
3	0.06	0.18	0.00	0.00	99.73	0.02	0.00
4	0.06	0.17	0.00	0.00	99.74	0.02	0.01
5	0.06	0.15	0.00	0.00	99.76	0.02	0.01
6	0.06	0.15	0.00	0.00	99.77	0.02	0.00
Average	0.06	0.18	0.00	0.00	99.73	0.02	0.01
Re-baseline	0	0	0	0	100	0	0

Table A-5. Monitor MS Tracer Gas Flow Rates

Experiment	Ar Flow
---	(cm^3/min)
80	10
86	10

At the end of the dissolution experiment, the H_2 calibration gas is re-sampled by the MS to see if the instrument is still reading the offgas concentrations accurately. Table A-6 through Table A-7 show multiple samples of the H_2 calibration gas read by the Monitor MS. Comparing the pre- and post-run calibration checks of the H_2 calibration gas shows that the Monitor MS is reading offgas concentrations accurately and the offgas concentrations measured during the experiment are valid.

Table A-6. Post-run Check of Calibration Gas for Experiment 80

Gas	H_2	N_2	NO	O_2	Ar	N_2O	NO_2
---	(%)	(%)	(%)	(%)	(%)	(%)	(%)
5% N_2-10% H_2-85% Ar	10.29	5.09	0.00	0.00	84.59	0.02	0.01
	10.32	5.04	0.00	0.00	84.60	0.02	0.02
	10.33	5.03	0.00	0.00	84.60	0.02	0.02
	10.35	5.00	0.00	0.00	84.61	0.02	0.02
	10.35	4.98	0.00	0.00	84.63	0.02	0.03

Table A-7. Post-run Check of Calibration Gas for Experiment 86

Gas	H_2	N_2	NO	O_2	Ar	N_2O	NO_2
---	(%)	(%)	(%)	(%)	(%)	(%)	(%)
5% N_2-10% H_2-85% Ar	10.43	5.00	0.01	0.00	84.55	0.00	0.01
	10.36	5.01	0.00	0.00	84.63	0.00	0.01
	10.52	5.01	0.00	0.00	84.46	0.00	0.01
	10.57	5.03	0.00	0.00	84.40	0.00	0.01
	10.56	5.02	0.00	0.00	84.42	0.00	0.00

Appendix B. MS Offgas Data for Experiment 80

Table B-1. Re-Baselined Normalized MS Offgas Concentration Data for Experiment 80

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	Ar	Total Offgas Flow	H_2	N_2	NO	O_2	N_2O	NO_2
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
0	5.603E-03	97.23	0.285	0.00	0.02	2.59	0.00	0.05	0.10
34	1.173E-02	97.08	0.301	0.00	0.02	2.77	0.00	0.05	0.07
68	1.822E-02	96.91	0.319	0.00	0.02	2.94	0.00	0.05	0.07
102	2.509E-02	96.73	0.338	0.00	0.02	3.13	0.00	0.05	0.07
136	3.240E-02	96.53	0.360	0.00	0.02	3.32	0.00	0.05	0.08
172	4.075E-02	96.21	0.394	0.00	0.02	3.64	0.00	0.05	0.08
204	4.869E-02	96.04	0.413	0.00	0.01	3.80	0.00	0.05	0.09
236	5.699E-02	95.88	0.430	0.00	0.01	3.98	0.00	0.05	0.07
269	6.591E-02	95.70	0.449	0.00	0.01	4.14	0.00	0.05	0.09
301	7.491E-02	95.55	0.466	0.00	0.01	4.31	0.00	0.05	0.08
334	8.453E-02	95.41	0.481	0.00	0.01	4.48	0.00	0.05	0.05
366	9.424E-02	95.20	0.504	0.00	0.01	4.67	0.00	0.05	0.07
398	1.044E-01	95.02	0.525	0.00	0.01	4.85	0.00	0.05	0.07
431	1.152E-01	94.82	0.547	0.00	0.01	5.04	0.00	0.05	0.08
463	1.262E-01	94.64	0.566	0.00	0.01	5.24	0.00	0.05	0.06
495	1.376E-01	94.41	0.593	0.00	0.01	5.45	0.00	0.05	0.09
527	1.495E-01	94.19	0.617	0.01	0.00	5.66	0.00	0.05	0.09
560	1.623E-01	93.97	0.642	0.00	0.00	5.87	0.00	0.05	0.10
592	1.752E-01	93.76	0.666	0.01	0.00	6.09	0.00	0.05	0.09
624	1.886E-01	93.52	0.693	0.01	0.00	6.33	0.00	0.05	0.09
657	2.029E-01	93.31	0.717	0.00	0.00	6.57	0.00	0.05	0.07
689	2.173E-01	93.06	0.746	0.00	0.00	6.80	0.00	0.05	0.09
721	2.322E-01	92.84	0.771	0.00	0.00	7.03	0.00	0.05	0.08
753	2.477E-01	92.59	0.800	0.01	0.00	7.25	0.00	0.05	0.10
785	2.637E-01	92.37	0.827	0.01	0.00	7.48	0.00	0.05	0.10
818	2.808E-01	92.10	0.858	0.00	0.00	7.73	0.00	0.05	0.11
851	2.986E-01	91.85	0.888	0.00	0.00	8.00	0.00	0.05	0.10
883	3.164E-01	91.53	0.925	0.00	0.00	8.29	0.00	0.05	0.11
915	3.350E-01	91.25	0.959	0.01	0.00	8.59	0.00	0.05	0.11
947	3.542E-01	90.94	0.996	0.01	0.00	8.89	0.00	0.05	0.11
980	3.748E-01	90.67	1.029	0.00	0.00	9.19	0.00	0.05	0.08
1012	3.954E-01	90.35	1.069	0.00	0.00	9.49	0.00	0.05	0.11
1044	4.168E-01	90.06	1.104	0.00	0.00	9.79	0.00	0.05	0.10

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	**Est. U Conc.**	**Ar**	**Total Offgas Flow**	**H_2**	**N_2**	**NO**	**O_2**	**N_2O**	**NO_2**
(sec)	**(g/L)**	**(vol %)**	**(cm^3/min)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**
1076	4.390E-01	89.75	1.142	0.00	0.00	10.08	0.00	0.05	0.11
1109	4.626E-01	89.43	1.182	0.00	0.00	10.41	0.00	0.05	0.10
1141	4.863E-01	89.06	1.228	0.01	0.00	10.75	0.00	0.05	0.13
1173	5.109E-01	88.74	1.269	0.00	0.00	11.12	0.00	0.05	0.09
1205	5.364E-01	88.33	1.321	0.00	0.00	11.49	0.00	0.05	0.12
1238	5.637E-01	87.95	1.370	0.00	0.00	11.86	0.00	0.05	0.12
1270	5.912E-01	87.57	1.420	0.00	0.00	12.26	0.00	0.06	0.12
1303	6.206E-01	87.17	1.472	0.00	0.00	12.67	0.00	0.06	0.10
1335	6.500E-01	86.79	1.522	0.00	0.00	13.04	0.00	0.06	0.11
1367	6.805E-01	86.41	1.573	0.00	0.00	13.39	0.00	0.06	0.14
1399	7.120E-01	86.07	1.619	0.00	0.00	13.76	0.00	0.06	0.11
1432	7.454E-01	85.68	1.672	0.00	0.00	14.16	0.00	0.06	0.11
1464	7.789E-01	85.21	1.735	0.00	0.00	14.62	0.00	0.06	0.11
1496	8.138E-01	84.68	1.809	0.01	0.00	15.12	0.00	0.06	0.14
1529	8.513E-01	84.20	1.877	0.00	0.00	15.63	0.00	0.06	0.11
1562	8.902E-01	83.66	1.954	0.01	0.00	16.13	0.00	0.06	0.14
1594	9.293E-01	83.19	2.020	0.00	0.00	16.60	0.00	0.06	0.14
1626	9.697E-01	82.76	2.083	0.00	0.00	17.03	0.00	0.06	0.14
1658	1.011E+00	82.36	2.142	0.00	0.00	17.44	0.00	0.06	0.13
1691	1.056E+00	81.92	2.207	0.00	0.00	17.86	0.00	0.06	0.15
1723	1.100E+00	81.49	2.272	0.00	0.00	18.32	0.00	0.06	0.12
1755	1.145E+00	81.01	2.344	0.01	0.00	18.76	0.00	0.07	0.16
1788	1.193E+00	80.56	2.414	0.00	0.00	19.25	0.00	0.06	0.13
1820	1.242E+00	80.07	2.489	0.00	0.00	19.73	0.00	0.06	0.14
1853	1.293E+00	79.58	2.566	0.00	0.00	20.21	0.00	0.06	0.14
1885	1.344E+00	79.13	2.638	0.00	0.00	20.65	0.00	0.07	0.15
1917	1.397E+00	78.70	2.707	0.00	0.00	21.09	0.00	0.07	0.14
1949	1.451E+00	78.27	2.776	0.00	0.00	21.50	0.00	0.07	0.15
1981	1.506E+00	77.81	2.852	0.00	0.00	21.96	0.00	0.07	0.15
2014	1.565E+00	77.31	2.936	0.00	0.00	22.46	0.00	0.07	0.16
2046	1.624E+00	76.85	3.013	0.00	0.00	22.92	0.00	0.07	0.16
2078	1.684E+00	76.41	3.087	0.00	0.00	23.36	0.00	0.07	0.16
2110	1.745E+00	75.95	3.166	0.00	0.00	23.80	0.00	0.07	0.17
2142	1.808E+00	75.53	3.241	0.01	0.00	24.23	0.00	0.08	0.16
2174	1.873E+00	75.06	3.322	0.01	0.00	24.68	0.00	0.08	0.17
2206	1.939E+00	74.56	3.412	0.00	0.00	25.20	0.00	0.08	0.16
2238	2.008E+00	74.05	3.504	0.00	0.00	25.71	0.00	0.08	0.15

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	Ar	Total Offgas Flow	H_2	N_2	NO	O_2	N_2O	NO_2
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
2271	2.080E+00	73.58	3.591	0.00	0.00	26.18	0.00	0.08	0.16
2303	2.151E+00	73.14	3.673	0.00	0.00	26.61	0.00	0.08	0.17
2335	2.224E+00	72.66	3.763	0.00	0.00	27.10	0.00	0.08	0.16
2367	2.299E+00	72.16	3.858	0.00	0.00	27.57	0.00	0.08	0.18
2399	2.376E+00	71.70	3.948	0.01	0.00	28.05	0.00	0.08	0.17
2431	2.455E+00	71.23	4.038	0.00	0.00	28.49	0.00	0.08	0.19
2463	2.535E+00	70.80	4.124	0.00	0.00	28.93	0.00	0.08	0.19
2496	2.620E+00	70.37	4.210	0.00	0.00	29.36	0.00	0.08	0.18
2528	2.704E+00	69.92	4.303	0.00	0.00	29.82	0.00	0.08	0.18
2560	2.789E+00	69.50	4.388	0.01	0.00	30.21	0.00	0.08	0.20
2592	2.877E+00	69.05	4.482	0.01	0.00	30.65	0.00	0.08	0.21
2624	2.966E+00	68.56	4.585	0.00	0.00	31.15	0.00	0.08	0.20
2656	3.057E+00	68.11	4.683	0.00	0.00	31.61	0.00	0.08	0.20
2688	3.150E+00	67.71	4.770	0.00	0.00	32.02	0.00	0.08	0.18
2720	3.245E+00	67.32	4.853	0.00	0.00	32.39	0.00	0.09	0.19
2752	3.342E+00	66.96	4.935	0.00	0.00	32.75	0.00	0.09	0.20
2784	3.440E+00	66.59	5.017	0.01	0.00	33.12	0.00	0.09	0.20
2816	3.539E+00	66.22	5.100	0.01	0.00	33.47	0.00	0.09	0.22
2851	3.648E+00	66.88	4.951	0.01	0.00	32.80	0.00	0.09	0.22
2882	3.743E+00	66.52	5.032	0.01	0.00	33.16	0.00	0.09	0.22
2914	3.843E+00	66.17	5.112	0.00	0.00	33.52	0.00	0.09	0.21
2946	3.944E+00	65.85	5.187	0.00	0.00	33.84	0.00	0.09	0.22
2978	4.047E+00	65.57	5.250	0.01	0.00	34.12	0.00	0.09	0.21
3010	4.151E+00	65.32	5.310	0.01	0.00	34.38	0.00	0.09	0.21
3042	4.256E+00	65.10	5.362	0.00	0.00	34.61	0.00	0.09	0.20
3073	4.359E+00	64.89	5.411	0.01	0.00	34.80	0.00	0.09	0.21
3105	4.466E+00	64.71	5.453	0.01	0.00	34.97	0.00	0.09	0.22
3137	4.574E+00	64.54	5.494	0.01	0.00	35.14	0.00	0.09	0.22
3168	4.679E+00	64.37	5.536	0.01	0.00	35.32	0.00	0.09	0.22
3200	4.789E+00	64.11	5.597	0.01	0.00	35.57	0.00	0.10	0.22
3232	4.899E+00	63.83	5.666	0.01	0.00	35.84	0.00	0.10	0.23
3263	5.008E+00	63.58	5.729	0.01	0.00	36.10	0.00	0.09	0.23
3295	5.121E+00	63.41	5.770	0.01	0.00	36.24	0.00	0.10	0.24
3327	5.236E+00	63.25	5.811	0.00	0.00	36.44	0.00	0.09	0.21
3358	5.347E+00	63.10	5.847	0.01	0.00	36.57	0.00	0.09	0.22
3390	5.462E+00	62.97	5.881	0.01	0.00	36.69	0.00	0.09	0.24
3422	5.578E+00	62.85	5.911	0.01	0.00	36.81	0.00	0.09	0.24

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	Ar	Total Offgas Flow	H_2	N_2	NO	O_2	N_2O	NO_2
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
3454	5.695E+00	62.68	5.953	0.00	0.00	36.99	0.00	0.09	0.23
3486	5.813E+00	62.53	5.993	0.01	0.00	37.14	0.00	0.10	0.22
3517	5.928E+00	62.40	6.027	0.01	0.00	37.26	0.00	0.10	0.24
3549	6.047E+00	62.27	6.058	0.01	0.00	37.39	0.00	0.10	0.24
3581	6.166E+00	62.18	6.081	0.01	0.00	37.48	0.00	0.10	0.24
3613	6.286E+00	62.11	6.100	0.01	0.00	37.55	0.00	0.10	0.24
3645	6.406E+00	62.08	6.109	0.00	0.00	37.59	0.00	0.10	0.23
3676	6.523E+00	62.05	6.117	0.01	0.00	37.64	0.00	0.10	0.22
3709	6.647E+00	61.96	6.138	0.01	0.00	37.69	0.00	0.10	0.24
3740	6.765E+00	61.93	6.148	0.01	0.00	37.73	0.00	0.10	0.24
3772	6.886E+00	61.91	6.154	0.01	0.00	37.73	0.00	0.10	0.26
3803	7.003E+00	61.87	6.162	0.01	0.00	37.75	0.00	0.10	0.27
3835	7.125E+00	61.83	6.173	0.01	0.00	37.82	0.00	0.10	0.24
3867	7.247E+00	61.80	6.181	0.01	0.00	37.85	0.00	0.10	0.25
3899	7.368E+00	61.82	6.177	0.01	0.00	37.84	0.00	0.10	0.23
3931	7.490E+00	61.82	6.175	0.01	0.00	37.82	0.00	0.10	0.25
3963	7.611E+00	61.85	6.168	0.01	0.00	37.77	0.00	0.10	0.27
3994	7.729E+00	61.93	6.148	0.01	0.00	37.74	0.00	0.10	0.23
4026	7.850E+00	61.94	6.144	0.00	0.00	37.72	0.00	0.10	0.24
4058	7.971E+00	61.88	6.160	0.01	0.00	37.76	0.00	0.10	0.25
4090	8.093E+00	61.86	6.166	0.01	0.00	37.79	0.00	0.10	0.25
4122	8.214E+00	61.87	6.163	0.01	0.00	37.77	0.00	0.10	0.26
4153	8.331E+00	61.94	6.145	0.01	0.00	37.72	0.00	0.10	0.25
4186	8.456E+00	62.02	6.123	0.01	0.00	37.62	0.00	0.10	0.25
4218	8.576E+00	62.12	6.097	0.01	0.00	37.53	0.00	0.10	0.25
4249	8.693E+00	62.19	6.080	0.01	0.00	37.48	0.00	0.09	0.23
4281	8.812E+00	62.25	6.065	0.01	0.00	37.39	0.00	0.09	0.26
4313	8.931E+00	62.36	6.037	0.01	0.00	37.30	0.00	0.10	0.24
4345	9.050E+00	62.49	6.001	0.01	0.00	37.16	0.00	0.09	0.24
4377	9.168E+00	62.62	5.970	0.01	0.00	37.03	0.00	0.10	0.25
4408	9.281E+00	62.76	5.934	0.01	0.00	36.89	0.00	0.09	0.25
4440	9.398E+00	62.85	5.911	0.01	0.00	36.79	0.00	0.10	0.25
4472	9.514E+00	62.93	5.890	0.01	0.00	36.70	0.00	0.09	0.26
4504	9.630E+00	63.04	5.862	0.01	0.00	36.60	0.00	0.09	0.25
4536	9.745E+00	63.18	5.829	0.01	0.00	36.48	0.00	0.09	0.25
4568	9.860E+00	63.34	5.788	0.01	0.00	36.32	0.00	0.09	0.24
4599	9.970E+00	63.52	5.743	0.01	0.00	36.13	0.00	0.09	0.25

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Cumulative Reaction Time	Est. U Conc.	Ar	Total Offgas Flow	H_2	N_2	NO	O_2	N_2O	NO_2
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
4631	1.008E+01	63.67	5.706	0.01	0.00	35.98	0.00	0.09	0.25
4664	1.020E+01	63.82	5.668	0.01	0.00	35.83	0.00	0.09	0.25
4696	1.031E+01	64.00	5.625	0.01	0.00	35.64	0.00	0.09	0.26
4728	1.042E+01	64.17	5.582	0.01	0.00	35.46	0.00	0.09	0.27
4759	1.053E+01	64.35	5.539	0.01	0.00	35.30	0.00	0.09	0.25
4791	1.063E+01	64.51	5.502	0.01	0.00	35.13	0.00	0.09	0.26
4823	1.074E+01	64.67	5.464	0.01	0.00	34.97	0.00	0.09	0.26
4855	1.085E+01	64.85	5.421	0.01	0.00	34.80	0.00	0.09	0.26
4887	1.096E+01	65.04	5.375	0.01	0.00	34.61	0.00	0.09	0.25
4919	1.106E+01	65.27	5.321	0.01	0.00	34.38	0.00	0.09	0.25
4951	1.117E+01	65.50	5.268	0.01	0.00	34.17	0.00	0.09	0.24
4983	1.127E+01	65.70	5.221	0.01	0.00	33.95	0.00	0.09	0.26
5015	1.137E+01	65.93	5.167	0.01	0.00	33.72	0.00	0.09	0.25
5047	1.147E+01	66.14	5.119	0.01	0.00	33.50	0.00	0.09	0.26
5079	1.157E+01	66.38	5.064	0.00	0.00	33.31	0.00	0.09	0.22
5111	1.167E+01	66.51	5.036	0.01	0.00	33.13	0.00	0.09	0.26
5143	1.177E+01	66.58	5.020	0.01	0.00	33.08	0.00	0.09	0.25
5175	1.187E+01	66.66	5.002	0.00	0.00	33.00	0.00	0.09	0.25
5207	1.197E+01	66.79	4.972	0.01	0.00	32.86	0.00	0.09	0.25
5239	1.207E+01	66.97	4.932	0.01	0.00	32.68	0.00	0.09	0.26
5271	1.216E+01	67.18	4.886	0.00	0.00	32.50	0.00	0.09	0.24
5303	1.226E+01	67.37	4.843	0.01	0.00	32.29	0.00	0.09	0.25
5335	1.235E+01	67.59	4.795	0.01	0.00	32.09	0.00	0.09	0.23
5367	1.245E+01	67.77	4.755	0.01	0.00	31.87	0.00	0.09	0.26
5399	1.254E+01	68.00	4.706	0.00	0.00	31.68	0.00	0.08	0.23
5431	1.263E+01	68.26	4.650	0.00	0.00	31.42	0.00	0.08	0.24
5463	1.272E+01	68.53	4.592	0.01	0.00	31.12	0.00	0.09	0.26
5495	1.281E+01	68.83	4.529	0.00	0.00	30.85	0.00	0.09	0.23
5527	1.290E+01	69.07	4.477	0.01	0.00	30.61	0.00	0.08	0.23
5559	1.299E+01	69.33	4.423	0.01	0.00	30.32	0.00	0.08	0.25
5591	1.308E+01	69.61	4.366	0.01	0.00	30.06	0.00	0.09	0.24
5623	1.316E+01	69.83	4.320	0.01	0.00	29.84	0.00	0.08	0.23
5655	1.325E+01	70.00	4.286	0.01	0.00	29.65	0.00	0.09	0.26
5687	1.333E+01	70.18	4.248	0.00	0.00	29.50	0.00	0.08	0.23
5719	1.341E+01	70.34	4.216	0.01	0.00	29.32	0.00	0.08	0.24
5751	1.350E+01	70.56	4.173	0.01	0.00	29.13	0.00	0.08	0.23
5783	1.358E+01	70.75	4.134	0.01	0.00	28.91	0.00	0.08	0.25

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Cumulative Reaction Time	**Est. U Conc.**	**Ar**	**Total Offgas Flow**	**H_2**	**N_2**	**NO**	**O_2**	**N_2O**	**NO_2**
(sec)	**(g/L)**	**(vol %)**	**(cm^3/min)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**
5815	1.366E+01	71.00	4.085	0.01	0.00	28.68	0.00	0.08	0.23
5847	1.374E+01	71.21	4.043	0.01	0.00	28.45	0.00	0.08	0.25
5879	1.382E+01	71.46	3.994	0.01	0.00	28.22	0.00	0.08	0.23
5911	1.390E+01	71.69	3.949	0.01	0.00	27.99	0.00	0.08	0.23
5943	1.397E+01	71.94	3.900	0.01	0.00	27.73	0.00	0.08	0.24
5975	1.405E+01	72.10	3.869	0.01	0.00	27.56	0.00	0.08	0.25
6007	1.413E+01	72.24	3.843	0.01	0.00	27.43	0.00	0.08	0.25
6039	1.420E+01	72.40	3.813	0.01	0.00	27.28	0.00	0.08	0.24
6071	1.428E+01	72.59	3.776	0.01	0.00	27.11	0.00	0.08	0.22
6103	1.435E+01	72.76	3.745	0.01	0.00	26.91	0.00	0.08	0.25
6135	1.442E+01	72.97	3.704	0.01	0.00	26.71	0.00	0.08	0.24
6167	1.450E+01	73.19	3.662	0.01	0.00	26.48	0.00	0.08	0.24
6200	1.457E+01	73.43	3.618	0.01	0.00	26.25	0.00	0.08	0.23
6234	1.465E+01	73.72	3.564	0.00	0.00	25.97	0.00	0.08	0.23
6318	1.483E+01	74.05	3.505	0.12	0.00	25.53	0.00	0.08	0.23
6350	1.490E+01	74.46	3.431	0.00	0.00	25.24	0.00	0.08	0.22
6382	1.496E+01	74.83	3.364	0.00	0.00	24.87	0.00	0.08	0.22
6414	1.503E+01	75.04	3.326	0.00	0.00	24.65	0.00	0.08	0.23
6446	1.509E+01	75.26	3.287	0.00	0.00	24.45	0.00	0.07	0.21
6478	1.516E+01	75.47	3.250	0.00	0.00	24.22	0.00	0.07	0.22
6509	1.522E+01	75.70	3.210	0.01	0.00	23.99	0.00	0.07	0.23
6541	1.528E+01	75.92	3.172	0.00	0.00	23.79	0.00	0.07	0.21
6573	1.535E+01	76.10	3.140	0.01	0.00	23.60	0.00	0.08	0.22
6605	1.541E+01	76.32	3.102	0.00	0.00	23.38	0.00	0.07	0.22
6637	1.547E+01	76.55	3.063	0.01	0.00	23.15	0.00	0.07	0.22
6669	1.553E+01	76.78	3.024	0.00	0.00	22.91	0.00	0.07	0.23
6700	1.559E+01	77.06	2.977	0.00	0.00	22.64	0.00	0.07	0.22
6733	1.565E+01	77.34	2.930	0.00	0.00	22.38	0.00	0.07	0.21
6764	1.570E+01	77.55	2.895	0.00	0.00	22.15	0.00	0.07	0.22
6796	1.576E+01	77.77	2.859	0.00	0.00	21.93	0.00	0.07	0.22
6829	1.582E+01	78.03	2.816	0.00	0.00	21.69	0.00	0.07	0.21
6861	1.587E+01	78.24	2.782	0.00	0.00	21.48	0.00	0.07	0.20
6893	1.592E+01	78.43	2.751	0.00	0.00	21.29	0.00	0.07	0.21
6925	1.598E+01	78.61	2.721	0.00	0.00	21.14	0.00	0.07	0.19
6957	1.603E+01	78.74	2.700	0.00	0.00	20.97	0.00	0.07	0.22
6989	1.609E+01	78.91	2.672	0.01	0.00	20.79	0.00	0.07	0.22
7021	1.614E+01	79.12	2.639	0.00	0.00	20.60	0.00	0.07	0.21

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Cumulative Reaction Time	**Est. U Conc.**	**Ar**	**Total Offgas Flow**	**H_2**	**N_2**	**NO**	**O_2**	**N_2O**	**NO_2**
(sec)	**(g/L)**	**(vol %)**	**(cm^3/min)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**
7053	1.619E+01	79.34	2.604	0.00	0.00	20.38	0.00	0.07	0.21
7085	1.624E+01	79.58	2.565	0.00	0.00	20.14	0.00	0.07	0.21
7117	1.629E+01	79.80	2.532	0.00	0.00	19.92	0.00	0.07	0.21
7149	1.634E+01	80.00	2.500	0.01	0.00	19.70	0.00	0.07	0.22
7181	1.639E+01	80.25	2.461	0.00	0.00	19.49	0.00	0.06	0.19
7213	1.644E+01	80.45	2.430	0.01	0.00	19.27	0.00	0.07	0.21
7245	1.648E+01	80.67	2.396	0.00	0.00	19.06	0.00	0.07	0.20
7277	1.653E+01	80.87	2.365	0.00	0.00	18.84	0.00	0.07	0.21
7310	1.658E+01	81.12	2.328	0.00	0.00	18.62	0.00	0.06	0.20
7342	1.662E+01	81.35	2.293	0.00	0.00	18.39	0.00	0.06	0.20
7374	1.667E+01	81.56	2.261	0.01	0.00	18.16	0.00	0.06	0.20
7406	1.671E+01	81.78	2.228	0.00	0.00	17.95	0.00	0.07	0.21
7438	1.676E+01	82.01	2.193	0.00	0.00	17.73	0.00	0.06	0.19
7470	1.680E+01	82.22	2.162	0.01	0.00	17.51	0.00	0.06	0.19
7502	1.684E+01	82.43	2.132	0.01	0.00	17.29	0.00	0.06	0.21
7534	1.688E+01	82.66	2.098	0.00	0.00	17.09	0.00	0.06	0.18
7566	1.692E+01	82.89	2.064	0.00	0.00	16.87	0.00	0.06	0.18
7598	1.697E+01	83.10	2.033	0.00	0.00	16.63	0.00	0.06	0.20
7630	1.700E+01	83.36	1.996	0.00	0.00	16.39	0.00	0.06	0.18
7662	1.704E+01	83.60	1.962	0.00	0.00	16.15	0.00	0.06	0.19
7694	1.708E+01	83.84	1.927	0.00	0.00	15.91	0.00	0.06	0.18
7726	1.712E+01	84.06	1.896	0.01	0.00	15.66	0.00	0.06	0.21
7758	1.716E+01	84.30	1.862	0.00	0.00	15.46	0.00	0.06	0.18
7790	1.719E+01	84.50	1.834	0.00	0.00	15.25	0.00	0.06	0.19
7822	1.723E+01	84.73	1.803	0.00	0.00	15.04	0.00	0.06	0.17
7854	1.726E+01	84.93	1.774	0.01	0.00	14.83	0.00	0.06	0.17
7886	1.730E+01	85.13	1.746	0.00	0.00	14.62	0.00	0.06	0.18
7918	1.733E+01	85.35	1.717	0.00	0.00	14.43	0.00	0.06	0.17
7950	1.737E+01	85.56	1.688	0.00	0.00	14.22	0.00	0.06	0.16
7982	1.740E+01	85.74	1.663	0.01	0.00	14.01	0.00	0.06	0.19
8015	1.743E+01	85.95	1.635	0.00	0.00	13.80	0.00	0.06	0.19
8047	1.746E+01	86.17	1.605	0.00	0.00	13.62	0.00	0.06	0.16
8079	1.750E+01	86.35	1.581	0.00	0.00	13.43	0.00	0.05	0.17
8110	1.753E+01	86.54	1.555	0.00	0.00	13.23	0.00	0.05	0.17
8142	1.756E+01	86.74	1.529	0.00	0.00	13.03	0.00	0.05	0.17
8174	1.759E+01	86.98	1.497	0.00	0.00	12.82	0.00	0.05	0.15
8206	1.762E+01	87.19	1.469	0.00	0.00	12.58	0.00	0.05	0.17

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Cumulative Reaction Time	Est. U Conc.	Ar	Total Offgas Flow	H_2	N_2	NO	O_2	N_2O	NO_2
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
8238	1.764E+01	87.42	1.439	0.01	0.00	12.36	0.00	0.05	0.16
8270	1.767E+01	87.61	1.415	0.00	0.00	12.16	0.00	0.05	0.18
8302	1.770E+01	87.80	1.389	0.00	0.00	11.97	0.00	0.05	0.17
8334	1.773E+01	88.04	1.359	0.00	0.00	11.75	0.00	0.05	0.15
8366	1.775E+01	88.26	1.331	0.00	0.00	11.54	0.00	0.05	0.15
8398	1.778E+01	88.45	1.306	0.00	0.00	11.33	0.00	0.05	0.16
8432	1.781E+01	88.50	1.299	0.01	0.00	11.28	0.00	0.05	0.16
8464	1.783E+01	88.71	1.273	0.00	0.00	11.08	0.00	0.05	0.15
8497	1.786E+01	88.90	1.249	0.00	0.00	10.88	0.00	0.05	0.16
8529	1.788E+01	89.12	1.221	0.00	0.00	10.68	0.00	0.05	0.14
8561	1.791E+01	89.33	1.195	0.00	0.00	10.47	0.00	0.05	0.15
8594	1.793E+01	89.53	1.169	0.00	0.00	10.27	0.00	0.05	0.14
8626	1.795E+01	89.73	1.145	0.00	0.00	10.11	0.00	0.05	0.12
8658	1.797E+01	89.88	1.126	0.00	0.00	9.93	0.00	0.05	0.13
8691	1.800E+01	90.05	1.105	0.00	0.00	9.75	0.00	0.05	0.15
8723	1.802E+01	90.23	1.083	0.00	0.00	9.59	0.00	0.05	0.13
8755	1.804E+01	90.41	1.061	0.00	0.00	9.40	0.00	0.05	0.14
8788	1.806E+01	90.58	1.041	0.00	0.00	9.23	0.00	0.05	0.14
8820	1.808E+01	90.73	1.021	0.00	0.00	9.08	0.00	0.05	0.13
8852	1.810E+01	90.90	1.001	0.00	0.00	8.93	0.00	0.05	0.12
8884	1.812E+01	91.05	0.983	0.00	0.00	8.76	0.00	0.05	0.14
8917	1.814E+01	91.22	0.962	0.00	0.00	8.58	0.00	0.05	0.14
8949	1.816E+01	91.41	0.940	0.00	0.00	8.42	0.00	0.05	0.12
8982	1.818E+01	91.59	0.919	0.00	0.00	8.24	0.00	0.04	0.12
9014	1.820E+01	91.76	0.898	0.00	0.00	8.05	0.00	0.05	0.13
9047	1.821E+01	91.94	0.877	0.00	0.00	7.89	0.00	0.05	0.13
9079	1.823E+01	92.09	0.859	0.00	0.00	7.74	0.00	0.05	0.12
9111	1.825E+01	92.24	0.842	0.00	0.00	7.61	0.00	0.04	0.11
9143	1.826E+01	92.35	0.828	0.00	0.00	7.48	0.00	0.05	0.12
9175	1.828E+01	92.48	0.813	0.00	0.00	7.34	0.00	0.04	0.13
9208	1.830E+01	92.63	0.796	0.00	0.00	7.21	0.00	0.04	0.12
9241	1.831E+01	92.75	0.781	0.00	0.00	7.06	0.00	0.05	0.13
9273	1.833E+01	92.91	0.763	0.00	0.00	6.92	0.00	0.05	0.12
9305	1.834E+01	93.05	0.747	0.00	0.00	6.79	0.00	0.05	0.11
9337	1.836E+01	93.19	0.731	0.00	0.00	6.66	0.00	0.04	0.11
9370	1.837E+01	93.31	0.717	0.00	0.00	6.51	0.00	0.05	0.13
9402	1.839E+01	93.47	0.699	0.00	0.00	6.37	0.00	0.04	0.12

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	Ar	Total Offgas Flow	H_2	N_2	NO	O_2	N_2O	NO_2
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
9434	1.840E+01	93.63	0.681	0.00	0.00	6.23	0.00	0.04	0.10
9467	1.841E+01	93.75	0.666	0.01	0.00	6.09	0.00	0.05	0.11
9499	1.843E+01	93.88	0.652	0.00	0.00	5.97	0.00	0.04	0.11
9532	1.844E+01	94.00	0.638	0.00	0.00	5.84	0.00	0.05	0.11
9564	1.845E+01	94.13	0.624	0.00	0.00	5.72	0.00	0.04	0.10
9596	1.846E+01	94.26	0.609	0.00	0.00	5.60	0.00	0.04	0.09
9629	1.848E+01	94.37	0.596	0.01	0.00	5.47	0.00	0.04	0.11
9661	1.849E+01	94.51	0.581	0.00	0.00	5.34	0.00	0.04	0.11
9694	1.850E+01	94.64	0.566	0.00	0.00	5.22	0.00	0.04	0.09
9726	1.851E+01	94.74	0.555	0.00	0.00	5.12	0.00	0.04	0.10
9758	1.852E+01	94.85	0.543	0.00	0.00	5.01	0.00	0.04	0.09
9790	1.853E+01	94.94	0.533	0.00	0.00	4.90	0.00	0.04	0.11
9823	1.854E+01	95.05	0.521	0.00	0.00	4.80	0.00	0.04	0.10
9855	1.855E+01	95.18	0.507	0.00	0.00	4.69	0.00	0.04	0.08
9888	1.856E+01	95.29	0.494	0.00	0.00	4.59	0.00	0.04	0.08
9920	1.857E+01	95.36	0.487	0.00	0.00	4.50	0.00	0.04	0.10
9952	1.858E+01	95.46	0.475	0.00	0.00	4.42	0.00	0.04	0.08
9984	1.859E+01	95.54	0.467	0.00	0.00	4.33	0.00	0.04	0.09
10017	1.860E+01	95.62	0.458	0.00	0.00	4.24	0.00	0.04	0.09
10049	1.861E+01	95.72	0.447	0.00	0.00	4.16	0.00	0.04	0.08
10081	1.862E+01	95.83	0.436	0.00	0.00	4.07	0.00	0.04	0.07
10114	1.863E+01	95.88	0.430	0.00	0.00	3.97	0.00	0.04	0.10
10146	1.864E+01	95.96	0.421	0.00	0.00	3.89	0.00	0.04	0.10
10179	1.864E+01	96.05	0.412	0.00	0.00	3.81	0.00	0.04	0.10
10211	1.865E+01	96.13	0.402	0.00	0.00	3.73	0.00	0.04	0.09
10244	1.866E+01	96.20	0.395	0.00	0.00	3.66	0.00	0.04	0.09
10276	1.867E+01	96.28	0.386	0.00	0.00	3.59	0.00	0.04	0.09
10308	1.868E+01	96.36	0.378	0.00	0.00	3.51	0.00	0.04	0.09
10340	1.868E+01	96.46	0.367	0.00	0.00	3.44	0.00	0.04	0.06
10373	1.869E+01	96.53	0.359	0.00	0.00	3.36	0.00	0.04	0.06
10405	1.870E+01	96.61	0.351	0.00	0.00	3.29	0.00	0.04	0.06
10437	1.870E+01	96.67	0.345	0.00	0.00	3.22	0.00	0.04	0.08
10470	1.871E+01	96.73	0.338	0.01	0.00	3.15	0.00	0.04	0.07
10502	1.872E+01	96.81	0.330	0.00	0.00	3.08	0.00	0.04	0.07
10534	1.872E+01	96.86	0.324	0.00	0.00	3.02	0.00	0.04	0.08
10567	1.873E+01	96.91	0.318	0.00	0.00	2.96	0.00	0.04	0.09
10599	1.874E+01	97.00	0.309	0.00	0.00	2.91	0.00	0.04	0.05

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Cumulative Reaction Time	Est. U Conc.	Ar	Total Offgas Flow	H_2	N_2	NO	O_2	N_2O	NO_2
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
10631	1.874E+01	97.01	0.308	0.00	0.00	2.85	0.00	0.04	0.10
10664	1.875E+01	97.07	0.302	0.00	0.00	2.80	0.00	0.04	0.09
10696	1.876E+01	97.12	0.296	0.00	0.00	2.75	0.00	0.04	0.08
10729	1.876E+01	97.21	0.287	0.00	0.00	2.70	0.00	0.04	0.05
10761	1.877E+01	97.24	0.284	0.00	0.00	2.65	0.00	0.04	0.07
10794	1.877E+01	97.31	0.277	0.00	0.00	2.59	0.00	0.04	0.06
10826	1.878E+01	97.36	0.272	0.00	0.00	2.53	0.00	0.04	0.07
10858	1.878E+01	97.42	0.265	0.00	0.00	2.48	0.00	0.04	0.06
10891	1.879E+01	97.47	0.260	0.00	0.00	2.43	0.00	0.04	0.06
10923	1.879E+01	97.51	0.256	0.00	0.00	2.38	0.00	0.04	0.07
10956	1.880E+01	97.54	0.252	0.00	0.00	2.33	0.00	0.04	0.09
10988	1.880E+01	97.61	0.244	0.00	0.00	2.29	0.00	0.04	0.05
11020	1.881E+01	97.64	0.241	0.00	0.00	2.24	0.00	0.04	0.07
11053	1.881E+01	97.71	0.234	0.00	0.00	2.20	0.00	0.04	0.05
11085	1.882E+01	97.74	0.231	0.00	0.00	2.15	0.00	0.04	0.06
11117	1.882E+01	97.80	0.225	0.00	0.00	2.11	0.00	0.04	0.06
11149	1.883E+01	97.82	0.223	0.00	0.00	2.06	0.00	0.04	0.07
11181	1.883E+01	97.88	0.217	0.00	0.00	2.02	0.00	0.04	0.06
11214	1.884E+01	97.92	0.212	0.00	0.00	1.98	0.00	0.04	0.06
11246	1.884E+01	97.96	0.208	0.00	0.00	1.94	0.00	0.04	0.06
11278	1.884E+01	97.97	0.207	0.00	0.00	1.90	0.00	0.04	0.08
11311	1.885E+01	98.03	0.201	0.00	0.00	1.87	0.00	0.04	0.06
11343	1.885E+01	98.06	0.197	0.00	0.00	1.83	0.00	0.04	0.07
11376	1.886E+01	98.12	0.191	0.00	0.00	1.79	0.00	0.04	0.05
11460	1.887E+01	98.04	0.200	0.13	0.00	1.73	0.00	0.04	0.07
11492	1.887E+01	98.23	0.181	0.00	0.00	1.71	0.00	0.04	0.03
11525	1.887E+01	98.25	0.178	0.00	0.00	1.63	0.00	0.04	0.07
11557	1.888E+01	98.30	0.173	0.00	0.00	1.60	0.00	0.04	0.06
11589	1.888E+01	98.34	0.169	0.00	0.00	1.57	0.00	0.04	0.05
11622	1.888E+01	98.37	0.165	0.00	0.00	1.54	0.00	0.04	0.04
11654	1.889E+01	98.39	0.164	0.00	0.00	1.51	0.00	0.04	0.06
11686	1.889E+01	98.43	0.159	0.00	0.00	1.48	0.00	0.04	0.05
11718	1.889E+01	98.45	0.157	0.00	0.00	1.45	0.00	0.04	0.05
11751	1.890E+01	98.48	0.155	0.00	0.00	1.42	0.00	0.04	0.06
11783	1.890E+01	98.51	0.151	0.00	0.00	1.40	0.00	0.04	0.05
11815	1.890E+01	98.55	0.147	0.00	0.00	1.37	0.00	0.04	0.04
11848	1.891E+01	98.58	0.144	0.00	0.00	1.34	0.00	0.03	0.04

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Cumulative Reaction Time	**Est. U Conc.**	**Ar**	**Total Offgas Flow**	**H_2**	**N_2**	**NO**	**O_2**	**N_2O**	**NO_2**
(sec)	**(g/L)**	**(vol %)**	**(cm^3/min)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**
11881	1.891E+01	98.61	0.141	0.00	0.00	1.32	0.00	0.04	0.04
11913	1.891E+01	98.62	0.140	0.00	0.00	1.30	0.00	0.04	0.05
11945	1.891E+01	98.63	0.139	0.00	0.00	1.27	0.00	0.04	0.06
11977	1.892E+01	98.64	0.138	0.01	0.00	1.24	0.00	0.04	0.07
12009	1.892E+01	98.68	0.134	0.00	0.00	1.23	0.00	0.04	0.05
12041	1.892E+01	98.71	0.131	0.00	0.00	1.20	0.00	0.04	0.05
12077	1.892E+01	98.81	0.121	0.01	0.00	1.08	0.00	0.04	0.06
12110	1.893E+01	98.86	0.116	0.00	0.00	1.07	0.00	0.04	0.04
12144	1.893E+01	98.88	0.114	0.00	0.00	1.05	0.00	0.04	0.04
12178	1.893E+01	98.89	0.112	0.00	0.00	1.03	0.00	0.04	0.04
12212	1.893E+01	98.92	0.109	0.00	0.00	1.01	0.00	0.04	0.04
12245	1.894E+01	98.93	0.108	0.00	0.00	0.98	0.00	0.04	0.04
12279	1.894E+01	98.97	0.104	0.00	0.00	0.96	0.00	0.04	0.04
12312	1.894E+01	98.98	0.103	0.00	0.00	0.94	0.00	0.04	0.04
12347	1.894E+01	99.01	0.100	0.00	0.00	0.92	0.00	0.03	0.03
12380	1.894E+01	99.01	0.100	0.00	0.00	0.90	0.00	0.04	0.05
12414	1.895E+01	99.03	0.098	0.00	0.00	0.88	0.00	0.04	0.05
12447	1.895E+01	99.06	0.095	0.00	0.00	0.86	0.00	0.04	0.04
12481	1.895E+01	99.09	0.092	0.00	0.00	0.84	0.00	0.03	0.03
12514	1.895E+01	99.11	0.090	0.00	0.00	0.82	0.00	0.03	0.04
12548	1.895E+01	99.12	0.089	0.00	0.00	0.80	0.00	0.03	0.04
12582	1.896E+01	99.13	0.088	0.00	0.00	0.78	0.00	0.03	0.06

Appendix C. MS Offgas Data for Experiment 86

Table C-1. Re-Baselined Normalized MS Offgas Concentration Data for Experiment 86

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Cumulative Reaction Time	Est. Fe Conc.	Ar	Total Offgas Flow	H_2	N_2	NO	O_2	N_2O	NO_2
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
19	0.000	99.99	0.000	0.00	0.00	0.00	0.00	0.00	0.01
53	0.000	100.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
86	0.006	98.62	0.140	0.00	1.38	0.00	0.00	0.00	0.00
120	0.015	99.64	0.036	0.00	0.34	0.00	0.00	0.00	0.01
153	0.018	99.72	0.028	0.00	0.28	0.00	0.00	0.00	0.00
187	0.021	99.54	0.046	0.00	0.45	0.01	0.00	0.00	0.00
221	0.026	99.39	0.062	0.00	0.54	0.07	0.00	0.00	0.00
255	0.033	99.20	0.081	0.00	0.60	0.19	0.00	0.00	0.01
288	0.042	98.96	0.105	0.00	0.64	0.37	0.00	0.01	0.02
322	0.053	98.71	0.131	0.00	0.66	0.59	0.00	0.01	0.03
355	0.066	98.40	0.162	0.00	0.68	0.83	0.00	0.02	0.06
388	0.083	98.13	0.191	0.00	0.70	1.07	0.00	0.03	0.07
422	0.102	97.86	0.219	0.00	0.71	1.30	0.00	0.03	0.09
456	0.124	97.61	0.245	0.00	0.72	1.52	0.00	0.04	0.11
489	0.148	97.38	0.269	0.00	0.73	1.73	0.00	0.04	0.12
523	0.174	97.16	0.293	0.00	0.73	1.94	0.00	0.05	0.12
556	0.202	96.95	0.314	0.00	0.73	2.13	0.00	0.05	0.13
590	0.233	96.73	0.338	0.00	0.73	2.32	0.00	0.06	0.16
623	0.265	96.55	0.358	0.00	0.74	2.49	0.00	0.06	0.16
657	0.300	96.36	0.378	0.00	0.74	2.66	0.00	0.06	0.18
690	0.336	96.20	0.395	0.00	0.73	2.82	0.00	0.07	0.18
724	0.374	96.00	0.417	0.00	0.73	2.98	0.00	0.07	0.22
757	0.413	95.84	0.434	0.00	0.74	3.13	0.00	0.07	0.22
791	0.455	95.68	0.452	0.00	0.74	3.28	0.00	0.07	0.24
824	0.498	95.53	0.468	0.00	0.74	3.41	0.00	0.07	0.25
858	0.543	95.39	0.484	0.00	0.74	3.55	0.00	0.08	0.25
891	0.588	95.25	0.499	0.00	0.74	3.67	0.00	0.08	0.27
927	0.640	94.99	0.528	0.00	0.69	3.94	0.00	0.08	0.30
959	0.688	94.85	0.543	0.00	0.73	4.03	0.00	0.08	0.31
991	0.737	94.74	0.555	0.00	0.73	4.13	0.00	0.08	0.31
1024	0.788	94.60	0.571	0.00	0.73	4.23	0.00	0.09	0.35
1056	0.840	94.50	0.582	0.00	0.74	4.32	0.00	0.09	0.35
1088	0.892	94.40	0.593	0.00	0.73	4.41	0.00	0.09	0.37

1120	0.946	94.30	0.605	0.00	0.73	4.50	0.00	0.09	0.38
1152	1.000	94.23	0.612	0.00	0.72	4.60	0.00	0.09	0.37
1185	1.057	94.13	0.624	0.00	0.71	4.67	0.00	0.09	0.39
1217	1.113	94.04	0.634	0.00	0.71	4.75	0.00	0.09	0.40
1249	1.170	93.99	0.639	0.00	0.70	4.83	0.00	0.09	0.38
1281	1.228	93.91	0.649	0.00	0.70	4.90	0.00	0.09	0.40
1313	1.286	93.85	0.655	0.00	0.68	4.98	0.00	0.09	0.40
1346	1.346	93.79	0.662	0.00	0.70	5.03	0.00	0.09	0.39
1378	1.406	93.71	0.671	0.00	0.70	5.08	0.00	0.09	0.41
1410	1.466	93.67	0.676	0.00	0.69	5.14	0.00	0.09	0.40
1442	1.527	93.61	0.682	0.00	0.69	5.20	0.00	0.09	0.41
1474	1.588	93.57	0.688	0.00	0.68	5.25	0.00	0.09	0.41
1506	1.649	93.53	0.692	0.00	0.68	5.30	0.00	0.09	0.41
1538	1.711	93.49	0.696	0.00	0.67	5.34	0.00	0.09	0.40
1570	1.774	93.45	0.701	0.00	0.66	5.39	0.00	0.09	0.41
1602	1.837	93.42	0.705	0.00	0.66	5.43	0.00	0.09	0.40
1634	1.900	93.37	0.710	0.00	0.66	5.46	0.00	0.09	0.42
1667	1.965	93.34	0.714	0.00	0.65	5.50	0.00	0.09	0.41
1699	2.029	93.34	0.713	0.00	0.65	5.53	0.00	0.09	0.38
1731	2.093	93.32	0.716	0.00	0.64	5.57	0.00	0.09	0.38
1763	2.157	93.29	0.720	0.00	0.64	5.59	0.00	0.09	0.39
1795	2.221	93.27	0.722	0.00	0.63	5.62	0.00	0.09	0.38
1827	2.286	93.24	0.725	0.00	0.63	5.65	0.00	0.09	0.39
1859	2.351	93.23	0.727	0.00	0.62	5.67	0.00	0.09	0.39
1891	2.416	93.22	0.727	0.00	0.62	5.69	0.00	0.09	0.38
1923	2.481	93.21	0.729	0.00	0.62	5.71	0.00	0.09	0.38
1955	2.546	93.20	0.729	0.00	0.61	5.72	0.00	0.09	0.38
1987	2.611	93.20	0.729	0.00	0.61	5.74	0.00	0.08	0.36
2019	2.676	93.18	0.732	0.00	0.61	5.75	0.00	0.08	0.38
2052	2.743	93.19	0.731	0.00	0.60	5.77	0.00	0.08	0.36
2084	2.809	93.19	0.731	0.00	0.60	5.78	0.00	0.08	0.35
2116	2.874	93.17	0.733	0.00	0.59	5.79	0.00	0.09	0.36
2148	2.939	93.17	0.733	0.00	0.59	5.79	0.00	0.08	0.36
2180	3.005	93.18	0.732	0.00	0.58	5.81	0.00	0.08	0.35
2212	3.070	93.18	0.732	0.00	0.58	5.81	0.00	0.08	0.35
2244	3.136	93.18	0.732	0.00	0.58	5.82	0.00	0.08	0.35
2277	3.203	93.17	0.733	0.00	0.57	5.82	0.00	0.08	0.36
2309	3.268	93.18	0.732	0.00	0.57	5.82	0.00	0.08	0.35
2341	3.334	93.18	0.732	0.00	0.56	5.82	0.00	0.08	0.36
2374	3.401	93.19	0.731	0.00	0.56	5.83	0.00	0.08	0.35
2406	3.466	93.19	0.730	0.00	0.56	5.82	0.00	0.08	0.35

2438	3.532	93.20	0.729	0.00	0.55	5.82	0.00	0.07	0.35
2470	3.597	93.21	0.728	0.00	0.55	5.82	0.00	0.07	0.34
2502	3.662	93.22	0.727	0.00	0.54	5.82	0.00	0.07	0.34
2534	3.726	93.24	0.725	0.00	0.54	5.82	0.00	0.07	0.34
2566	3.791	93.25	0.724	0.00	0.53	5.82	0.00	0.07	0.34
2598	3.856	93.25	0.724	0.00	0.53	5.81	0.00	0.07	0.35
2631	3.922	93.27	0.721	0.00	0.53	5.81	0.00	0.07	0.33
2663	3.987	93.29	0.720	0.00	0.52	5.80	0.00	0.07	0.32
2695	4.051	93.29	0.720	0.00	0.52	5.79	0.00	0.07	0.33
2727	4.115	93.32	0.716	0.00	0.51	5.79	0.00	0.07	0.31
2759	4.179	93.34	0.714	0.00	0.51	5.78	0.00	0.06	0.31
2791	4.243	93.35	0.712	0.00	0.50	5.77	0.00	0.07	0.31
2823	4.306	93.36	0.711	0.00	0.50	5.76	0.00	0.06	0.30
2856	4.372	93.35	0.712	0.00	0.50	5.75	0.00	0.07	0.33
2888	4.435	93.38	0.708	0.00	0.50	5.74	0.00	0.06	0.31
2920	4.498	93.41	0.706	0.00	0.49	5.73	0.00	0.06	0.30
2952	4.561	93.42	0.704	0.00	0.49	5.72	0.00	0.06	0.30
2984	4.624	93.43	0.703	0.00	0.49	5.70	0.00	0.06	0.31
3016	4.687	93.46	0.700	0.00	0.49	5.69	0.00	0.06	0.30
3048	4.749	93.47	0.699	0.00	0.48	5.68	0.00	0.06	0.31
3080	4.811	93.49	0.696	0.00	0.48	5.67	0.00	0.06	0.30
3113	4.875	93.52	0.693	0.00	0.47	5.66	0.00	0.06	0.29
3145	4.937	93.54	0.691	0.00	0.47	5.65	0.00	0.06	0.29
3177	4.999	93.56	0.688	0.00	0.47	5.63	0.00	0.06	0.28
3209	5.060	93.58	0.686	0.00	0.47	5.61	0.00	0.05	0.28
3241	5.121	93.57	0.687	0.00	0.47	5.59	0.00	0.06	0.31
3273	5.182	93.62	0.682	0.00	0.46	5.58	0.00	0.05	0.28
3305	5.243	93.63	0.680	0.00	0.46	5.57	0.00	0.05	0.28
3338	5.306	93.65	0.678	0.00	0.46	5.55	0.00	0.05	0.29
3370	5.366	93.68	0.674	0.00	0.45	5.54	0.00	0.05	0.28
3402	5.426	93.68	0.675	0.00	0.45	5.52	0.00	0.06	0.30
3434	5.486	93.70	0.672	0.00	0.45	5.50	0.00	0.05	0.29
3466	5.546	93.73	0.669	0.00	0.45	5.48	0.00	0.05	0.29
3499	5.608	93.75	0.667	0.00	0.44	5.46	0.00	0.05	0.29
3531	5.667	93.76	0.665	0.00	0.44	5.45	0.00	0.05	0.29
3563	5.727	93.81	0.660	0.00	0.44	5.44	0.00	0.05	0.27
3595	5.785	93.81	0.659	0.00	0.43	5.42	0.00	0.05	0.29
3627	5.844	93.85	0.655	0.00	0.43	5.41	0.00	0.05	0.26
3659	5.903	93.87	0.654	0.00	0.43	5.39	0.00	0.04	0.28
3691	5.961	93.90	0.650	0.00	0.43	5.37	0.00	0.04	0.26
3723	6.019	93.91	0.648	0.00	0.42	5.36	0.00	0.04	0.26

3757	6.080	93.92	0.647	0.00	0.42	5.34	0.00	0.04	0.28
3789	6.138	93.95	0.644	0.00	0.42	5.32	0.00	0.05	0.26
3822	6.197	93.97	0.641	0.00	0.42	5.30	0.00	0.04	0.26
3854	6.254	93.99	0.639	0.00	0.39	5.29	0.00	0.04	0.27
3886	6.311	94.01	0.637	0.00	0.42	5.27	0.00	0.04	0.26
3918	6.368	94.02	0.636	0.00	0.42	5.25	0.00	0.04	0.27
3950	6.425	94.06	0.632	0.00	0.41	5.23	0.00	0.04	0.26
3982	6.481	94.09	0.628	0.00	0.41	5.22	0.00	0.04	0.25
4014	6.537	94.09	0.628	0.00	0.41	5.20	0.00	0.04	0.26
4047	6.595	94.12	0.625	0.00	0.40	5.18	0.00	0.04	0.26
4079	6.650	94.15	0.622	0.00	0.40	5.16	0.00	0.04	0.25
4112	6.707	94.15	0.622	0.00	0.40	5.14	0.00	0.04	0.27
4144	6.763	94.17	0.620	0.00	0.40	5.13	0.00	0.04	0.27
4176	6.816	94.55	0.577	0.00	0.08	5.14	0.00	0.04	0.19
4208	6.861	95.90	0.427	0.00	0.00	3.88	0.00	0.03	0.19
4240	6.893	97.22	0.286	0.00	0.00	2.61	0.00	0.02	0.15
4272	6.914	98.10	0.193	0.00	0.00	1.75	0.00	0.01	0.14
4308	6.930	98.77	0.124	0.00	0.00	1.09	0.00	0.01	0.12
4342	6.941	99.07	0.094	0.00	0.00	0.80	0.00	0.01	0.12
4377	6.949	99.26	0.075	0.00	0.00	0.65	0.00	0.01	0.09
4411	6.956	99.32	0.068	0.00	0.00	0.56	0.00	0.01	0.11
4444	6.961	99.41	0.059	0.00	0.00	0.51	0.00	0.00	0.08
4478	6.967	99.44	0.056	0.00	0.00	0.47	0.00	0.00	0.09
4512	6.972	99.48	0.053	0.00	0.00	0.45	0.00	0.00	0.08
4546	6.977	99.49	0.051	0.00	0.00	0.43	0.00	0.00	0.08
4579	6.982	99.51	0.049	0.00	0.00	0.42	0.00	0.00	0.07
4613	6.986	99.51	0.049	0.00	0.00	0.40	0.00	0.00	0.08
4646	6.991	99.51	0.049	0.00	0.00	0.39	0.00	0.01	0.09
4680	6.995	99.55	0.045	0.00	0.00	0.39	0.00	0.00	0.07

Appendix D. Raman Calibration and Sampling Method

The Raman spectrometer was calibrated using a set of calibration gases as shown in Table 2-3. Due to the nature of the Raman technique, the instrument only needs to be calibrated once for the intensities (or quantities) of the calibration gases. The wavelengths for the various calibration gases are known and also remain fixed. As an additional check before and after each experiment, air, 99.9 vol % CO_2, and/or a 2.67 vol % H_2 gas (balance Ar) were analyzed using the Raman cell to ensure the calibration was still good. If the calibration checks were off for these gases, the Raman calibration model was adjusted for those gases after the run. For the Al dissolutions performed in Experiments 109-Phase 1 and 109-Phase 2, the calibration checks are shown in Table D-1. The calibration check indicates if the calibration was successful and provides an indication of the variance of the measurements since the calibration gas is analyzed for several samples.

The Raman readings should be positive and sum to 100% except for the 2.67 vol % H_2 gas which is 97.33 vol % Ar (which is not detected by the Raman spectrometer). Due to the noise in the Raman signal, any raw readings that are less than zero are fixed to zero and then all the gas readings for H_2, NO_2, N_2, O_2, N_2O, NO, CO_2, CO, H_2O and NH_3 are normalized to 100% except for the 2.67 vol % H_2 gas. These fixed and normalized Raman readings are the values reported in Table D-1 except for the 2.67 vol % H_2 gas where the raw readings are provided. Due to rounding to the nearest hundredth, the numbers in the table may not sum exactly to 100 vol % but all the decimal places were carried in the calculations performed for this report.

The total offgas flow is calculated from the fixed normalized sum of the CO_2 and CO concentrations divided into the CO_2 tracer flow rate coming into the system as shown in Table D-2. The noise in the concentrations measured by the Raman spectrometer propagates into the total offgas flow rate so moving averages of the total offgas flow rates were performed using equation A-1:

$$\text{Offgas flow rate}_{t_i}(\text{cm}^3/\text{min}) = \frac{\sum_{k=t_{i-1}}^{t_{i+1}} \text{Offgas flow rate}_k}{3} \quad \text{(A-1)}$$

where Offgas flow rate = offgas generated by the dissolution in cm^3/min
t_i = time at integer time step i
k= integer time step t_{i-1}, t_i, and t_{i+1}.

The moving average offgas flow rates and fixed normalized moving average Raman offgas concentrations for Experiment 109-Phase 1 and 109-Phase-2 are shown in Appendix E and F, respectively.

Table D-1. Pre-run Check of Calibration Gases for Al Dissolution Experiments 109-Phase 1 & 2

Gas Description	Exp.	H_2 (%)	NO_2 (%)	N_2 (%)	O_2 (%)	N_2O (%)	NO (%)	CO_2 (%)	CO (%)	H_2O (%)	NH_3 (%)
99.9% CO_2	109-Phase 1	0.00	0.06	0.62	0.00	0.00	0.00	**99.17**	0.14	0.00	0.00
	109-Phase 1	0.08	0.07	1.16	1.61	0.00	0.26	**96.26**	0.30	0.25	0.00
	109-Phase 1	0.00	0.06	0.25	1.92	0.14	0.00	**96.95**	0.30	0.27	0.12
	109-Phase 1	0.00	0.05	0.09	0.64	1.23	0.00	**97.92**	0.00	0.08	0.00
	109-Phase 1	0.05	0.04	0.17	0.71	0.10	0.00	**98.88**	0.06	0.00	0.00
	109-Phase 1	0.00	0.08	0.37	0.57	0.00	0.00	**98.09**	0.67	0.15	0.07
	109-Phase 1	0.03	0.06	1.16	0.50	0.00	0.00	**98.24**	0.00	0.00	0.00
	109-Phase 1	0.23	0.06	0.24	0.81	0.00	0.00	**98.25**	0.00	0.41	0.00
	109-Phase 2	0.00	0.05	0.61	0.28	0.18	0.00	**98.84**	0.00	0.04	0.00
	109-Phase 2	0.05	0.04	1.11	1.00	0.34	0.00	**96.40**	0.48	0.46	0.12
	109-Phase 2	0.14	0.06	0.90	0.96	0.85	0.00	**96.72**	0.00	0.32	0.05
	109-Phase 2	0.11	0.05	0.63	0.76	0.01	0.00	**97.96**	0.00	0.48	0.00
	109-Phase 2	0.23	0.05	0.35	0.82	0.00	0.76	**97.53**	0.00	0.05	0.21
	109-Phase 2	0.18	0.05	0.32	0.37	1.43	0.00	**97.62**	0.00	0.00	0.03
	109-Phase 2	0.32	0.05	1.30	0.16	0.00	0.00	**97.80**	0.00	0.37	0.00
	109-Phase 2	0.59	0.06	1.10	0.52	0.00	0.00	**97.04**	0.56	0.13	0.00
Air (78.0% N_2-21.0% O_2-0.9% Ar)	109-Phase 1	0.00	0.00	**78.25**	**20.21**	0.49	0.23	0.77	0.00	0.00	0.05
	109-Phase 1	0.11	0.00	**78.94**	**20.66**	0.00	0.00	0.27	0.00	0.00	0.02
	109-Phase 1	0.03	0.00	**77.90**	**20.82**	0.00	0.00	1.13	0.04	0.08	0.00
	109-Phase 1	0.17	0.01	**78.47**	**20.33**	0.34	0.00	0.28	0.20	0.20	0.00
	109-Phase 1	0.06	0.02	**77.77**	**20.51**	0.00	0.00	0.98	0.65	0.01	0.00
	109-Phase 1	0.11	0.00	**77.14**	**19.76**	0.22	1.15	0.72	0.64	0.23	0.04
	109-Phase 1	0.17	0.00	**76.66**	**19.47**	0.00	2.02	1.52	0.00	0.15	0.00
	109-Phase 1	0.00	0.00	**78.19**	**20.85**	0.00	0.00	0.92	0.00	0.04	0.00
	109-Phase 2	0.19	0.01	**77.34**	**20.77**	0.19	0.00	1.07	0.43	0.00	0.00
	109-Phase 2	0.00	0.00	**78.02**	**19.97**	0.00	0.10	0.73	0.75	0.27	0.16
	109-Phase 2	0.09	0.00	**78.38**	**19.26**	0.00	0.00	1.92	0.00	0.35	0.00
	109-Phase 2	0.00	0.00	**79.39**	**19.96**	0.00	0.00	0.65	0.00	0.00	0.00
	109-Phase 2	0.16	0.00	**74.36**	**24.21**	0.48	0.00	0.36	0.31	0.11	0.00
	109-Phase 2	0.00	0.00	**78.01**	**19.57**	0.00	0.00	1.73	0.17	0.52	0.00
	109-Phase 2	0.08	0.02	**78.25**	**19.23**	0.00	1.32	0.86	0.08	0.17	0.00
	109-Phase 2	0.23	0.00	**77.69**	**19.71**	0.27	1.21	0.46	0.27	0.13	0.02
2.67% H_2-97.33% Ar	109-Phase 1	**2.74**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 1	**2.83**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 1	**2.25**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 1	**2.80**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 1	**2.47**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 1	**2.71**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 1	**2.67**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 1	**2.73**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 2	**2.89**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 2	**2.57**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 2	**2.64**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 2	**2.53**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 2	**2.72**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 2	**2.64**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 2	**2.50**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	109-Phase 2	**2.48**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The values in Table D-1 should be constant since the Raman is reading constant sources (calibration gases) without being connected to the dissolution equipment. The variance seen in these values represent the instrument noise and should not be counted as part of the process noise or variance. To estimate the measurement uncertainty of the Raman spectroscopy, the pre-run check values of Table D-1 were compared to the standard values across Experiments 109 Phase 1 and 2. Sample standard deviations of the measured concentrations with respect to the calibrated concentrations for the data were calculated. These sample standard deviations were then doubled to get an idea of the variability in the Raman spectroscopy concentration measurements. Table D-3 shows the sample standard deviation of the measured concentrations with respect to their calibrated values. For the H_2 gas, the 2σ values or twice the standard deviation is 0.32 vol%. The 2σ value for O_2 and N_2 is < 3 vol % and the 2σ value for CO_2 is < 4.7 vol %.

Table D-2. Raman Tracer Gas Flow Rates

Experiment	CO_2 Flow (cm^3/min)
109-P1	20
109-P2	20

Table D-3. Standard Deviation of Raman Concentrations with Respect to Calibrated Values

Gas	Standard Deviation (σ) (vol %)	2*Standard Deviation (2σ) (vol %)
CO_2	2.33	4.66
N_2	1.11	2.22
O_2	1.32	2.64
H_2	0.16	0.32

Appendix E. Raman Offgas Data for Experiment 109-Phase 1

As discussed in Appendix D, the Raman readings should be positive and sum to 100% except in cases where there is significant Ar present. Due to the noise in the Raman signal, any raw readings that are less than zero are fixed to zero and then all the gas readings for H_2, NO_2, N_2, O_2, N_2O, and NO are normalized to 100 vol %. Even with these corrections, the Raman readings have noise in them. To reduce this noise, moving averages of the fixed and normalized readings were performed using equation E-1:

$$\text{Gas}_{t_i}(\text{vol\%}) = \frac{\sum_{k=t_{i-2}}^{t_{i+2}} \text{Gas}_k}{5} \quad \text{(E-1)}$$

where Gas = H_2, NO_2, N_2, O_2, N_2O, NO concentrations (vol %)
t_i = time at integer time step i
k= integer time step t_{i-2}, t_{i-1}, t_i, t_{i+1}, and t_{i+2}.

These moving averages do not eliminate all the noise but smooth the values so comparisons and calculations can be performed. The fixed, normalized, and moving average Raman gas concentrations are reported in Table E-1 for Experiment 109-Phase 1. Due to rounding to the nearest hundredth, the numbers in the table may not sum to exactly 100 vol % but all the decimal places were carried in the calculations performed for this report.

Table E-1. Fixed Normalized Moving Average Raman Data for Experiment 109-Phase 1

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. Al Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(M)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
1	0.0005	80.22	4.93	0.21	4.43	7.77	0.49	8.02	79.09
13	0.0010	79.98	5.01	0.29	4.41	8.84	0.49	6.28	79.71
24	0.0014	80.24	4.92	0.29	4.45	9.07	0.49	5.82	79.88
36	0.0019	80.52	4.84	0.66	4.33	9.30	0.83	6.01	78.87
48	0.0024	80.55	4.83	0.80	4.27	9.05	1.63	6.24	78.01
60	0.0029	80.23	4.93	1.10	4.06	8.76	1.46	8.50	76.11
72	0.0033	77.97	5.69	1.01	3.68	8.05	1.46	13.79	72.02
83	0.0039	69.20	9.78	1.42	3.26	8.17	1.46	19.15	66.55
95	0.005	52.27	24.29	1.41	2.93	7.03	0.95	23.93	63.75
107	0.008	33.48	53.11	1.65	2.57	6.56	0.15	28.23	60.85
119	0.015	20.06	90.53	1.72	2.32	5.89	0.00	31.02	59.05
131	0.026	13.64	134.87	2.00	2.26	6.19	0.00	31.62	57.93
143	0.042	10.51	177.89	2.19	2.21	5.72	0.00	30.99	58.90
154	0.060	8.45	220.87	2.37	2.21	6.03	0.05	30.53	58.81
166	0.083	7.72	239.85	2.54	2.16	6.15	0.05	30.73	58.37
178	0.108	7.05	266.06	2.70	2.14	5.99	0.25	31.16	57.75
190	0.134	7.08	264.80	2.84	2.07	5.63	0.25	30.94	58.27
202	0.162	7.86	244.91	2.76	2.00	5.79	0.25	30.74	58.46

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. Al Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(M)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
214	0.183	7.90	242.86	2.76	1.97	5.68	0.20	31.13	58.27
226	0.206	8.41	226.94	2.79	1.97	5.76	0.20	31.05	58.23
238	0.231	8.54	224.38	2.77	1.95	5.61	0.00	30.89	58.79
250	0.250	10.03	180.97	2.72	1.94	5.67	0.00	30.97	58.71
261	0.265	10.29	174.82	2.74	1.95	5.52	0.00	30.80	58.99
273	0.282	10.80	166.69	2.66	1.95	5.55	0.00	30.89	58.95
285	0.299	10.49	172.48	2.55	1.93	5.51	0.00	30.80	59.22
297	0.315	10.28	177.40	2.66	1.94	5.54	0.00	30.77	59.10
309	0.334	10.02	181.26	2.70	1.96	5.52	0.10	30.55	59.17
321	0.352	11.48	160.61	2.65	1.95	5.47	0.10	30.69	59.14
333	0.365	11.69	155.71	2.73	1.96	5.58	0.10	30.68	58.95
345	0.381	11.53	158.37	2.84	2.02	5.28	0.10	31.40	58.37
357	0.398	10.80	166.88	2.69	2.00	5.03	0.10	31.84	58.34
369	0.413	12.78	140.30	2.64	2.00	4.98	0.00	32.20	58.18
381	0.426	12.84	139.17	2.62	2.02	4.84	0.40	32.17	57.95
393	0.439	12.57	143.16	2.61	2.11	5.36	0.40	33.70	55.82
405	0.455	12.28	145.72	2.44	2.11	5.33	0.40	33.02	56.70
417	0.469	14.25	124.32	2.46	2.13	5.54	0.40	32.31	57.15
429	0.479	15.73	107.53	2.45	2.09	5.67	0.40	32.17	57.22
441	0.489	14.74	119.13	2.51	2.09	6.01	0.00	32.11	57.28
453	0.502	13.09	135.56	2.47	2.00	5.28	0.00	30.56	59.69
465	0.517	11.91	147.99	2.56	1.99	5.72	0.00	30.42	59.31
477	0.531	14.05	127.74	2.56	2.00	5.58	0.00	30.82	59.04
489	0.543	14.59	121.04	2.59	2.10	5.68	0.00	31.14	58.48
501	0.553	15.00	115.99	2.59	2.12	5.48	0.02	31.27	58.52
513	0.566	12.74	138.03	2.71	2.17	5.89	0.02	31.77	57.44
525	0.580	13.35	132.18	2.68	2.18	5.73	0.02	31.45	57.94
537	0.593	15.74	114.77	2.65	2.22	6.10	0.02	31.94	57.07
549	0.603	16.26	107.63	2.53	2.15	5.79	2.15	31.09	56.29
561	0.613	15.27	118.05	2.46	2.15	5.84	2.14	31.08	56.33
573	0.627	12.83	135.97	2.31	2.11	5.77	2.14	30.44	57.24
585	0.640	13.28	131.07	2.35	2.18	6.05	2.14	31.90	55.38
597	0.652	14.10	122.18	2.28	2.16	5.71	2.14	30.84	56.87
609	0.664	15.99	107.05	2.38	2.23	5.74	0.00	31.52	58.13
621	0.674	16.00	106.95	2.32	2.24	5.76	0.00	31.50	58.18
633	0.684	15.24	115.12	2.23	2.22	5.68	0.00	31.47	58.40
645	0.697	13.60	127.51	2.25	2.23	5.59	0.00	30.58	59.34

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. Al Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(M)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
658	0.711	16.07	111.54	2.33	2.23	5.89	0.00	31.17	58.38
670	0.720	16.52	106.32	2.17	2.20	5.75	0.43	31.06	58.39
682	0.730	16.61	105.50	2.19	2.24	5.87	0.43	30.80	58.47
694	0.742	16.46	106.15	2.27	2.28	5.61	0.43	30.38	59.03
706	0.752	18.07	93.79	2.20	2.25	5.41	0.43	29.97	59.73
718	0.760	20.43	78.26	2.02	2.27	5.49	0.43	29.86	59.93
730	0.767	18.42	90.69	2.05	2.30	5.82	0.00	29.95	59.88
742	0.777	17.00	101.18	2.00	2.31	5.72	0.00	30.91	59.06
755	0.789	14.53	117.80	1.95	2.31	6.25	0.03	31.28	58.17
767	0.801	14.37	119.27	1.86	2.30	6.48	0.03	31.51	57.82
779	0.812	15.14	112.93	1.98	2.31	6.34	0.03	31.47	57.86
791	0.823	16.27	103.51	2.01	2.35	6.39	0.03	31.85	57.38
803	0.833	16.75	99.51	2.03	2.31	6.27	0.03	31.31	58.05
815	0.842	16.79	99.22	1.90	2.33	5.91	0.09	31.33	58.43
827	0.852	16.56	100.82	1.92	2.33	5.87	0.09	31.45	58.34
840	0.863	16.40	102.11	1.90	2.33	5.81	0.09	31.52	58.35
852	0.873	15.75	107.23	1.90	2.36	6.14	0.09	31.27	58.23
864	0.884	15.50	109.08	1.93	2.39	6.31	0.09	30.82	58.46
876	0.895	15.61	108.25	1.96	2.39	6.33	0.00	30.65	58.68
888	0.905	16.00	104.97	1.85	2.40	6.34	0.00	30.58	58.82
901	0.916	15.74	107.16	1.81	2.49	6.71	0.00	31.41	57.58
913	0.927	16.39	102.64	1.76	2.45	6.31	0.00	30.77	58.70
925	0.937	16.71	100.28	1.68	2.46	6.17	0.00	30.70	58.98
937	0.946	17.66	93.30	1.69	2.48	6.32	0.00	30.85	58.65
949	0.956	16.65	100.91	1.70	2.49	6.58	0.00	31.03	58.20
962	0.967	15.90	106.81	1.59	2.43	6.69	0.00	30.32	58.97
974	0.978	15.27	111.17	1.56	2.52	7.16	0.00	31.57	57.18
986	0.989	16.40	102.80	1.55	2.52	7.37	0.00	32.03	56.52
998	0.998	16.99	98.04	1.62	2.57	7.74	0.00	32.68	55.39
1011	1.008	17.54	94.19	1.57	2.65	7.73	0.00	33.54	54.51
1023	1.018	17.55	94.13	1.54	2.65	7.39	0.17	33.33	54.93
1035	1.027	17.53	94.25	1.52	2.67	7.41	0.17	33.27	54.96
1048	1.037	18.18	90.52	1.49	2.71	7.43	0.17	33.13	55.07
1060	1.046	18.30	89.83	1.43	2.65	7.46	0.17	31.91	56.40
1072	1.054	20.78	77.40	1.44	2.62	7.29	0.17	30.87	57.62
1084	1.062	20.89	76.85	1.54	2.65	7.54	0.00	31.73	56.55
1097	1.069	20.35	80.21	1.39	2.57	7.10	0.18	30.81	57.94

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. Al Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(M)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
1109	1.078	17.79	93.27	1.39	2.53	7.22	0.18	30.92	57.75
1122	1.089	17.05	97.41	1.38	2.57	6.97	0.18	31.46	57.44
1134	1.098	17.28	95.91	1.47	2.63	6.70	0.18	31.97	57.06
1146	1.107	18.45	88.70	1.47	2.65	6.79	0.18	30.60	58.30
1159	1.117	20.18	80.24	1.52	2.67	6.79	0.00	31.16	57.87
1171	1.124	19.99	81.50	1.53	2.74	6.73	0.00	31.21	57.78
1183	1.132	19.54	83.92	1.43	2.76	6.59	0.00	31.28	57.93
1196	1.142	18.06	90.91	1.36	2.72	7.10	0.00	30.87	57.94
1208	1.150	18.46	88.36	1.38	2.78	7.19	0.00	31.98	56.68
1220	1.159	19.29	84.07	1.33	2.87	7.32	0.00	32.20	56.28
1233	1.168	19.87	80.98	1.26	2.89	7.66	0.00	31.31	56.88
1245	1.175	22.40	70.35	1.24	2.96	7.69	0.00	31.96	56.14
1257	1.182	23.35	66.58	1.37	2.95	7.33	0.00	31.62	56.73
1270	1.189	25.09	59.81	1.26	2.90	7.00	0.00	31.18	57.67
1282	1.195	23.10	67.49	1.33	2.91	7.11	0.00	30.65	58.00
1295	1.202	25.03	62.05	1.19	2.93	7.19	0.00	30.89	57.80
1307	1.208	25.20	61.52	1.26	2.87	7.27	0.00	30.20	58.40
1319	1.213	25.06	62.24	1.17	2.99	7.37	0.00	31.75	56.72
1332	1.221	22.64	69.54	1.18	3.03	7.18	0.07	31.90	56.65
1344	1.228	21.25	74.46	1.18	3.00	7.49	0.07	32.42	55.85
1357	1.236	22.07	70.61	1.30	2.99	7.37	0.07	32.79	55.48
1369	1.243	22.08	70.59	1.28	3.08	7.97	0.07	33.62	53.99
1382	1.250	23.64	65.21	1.30	3.11	7.69	0.09	33.78	54.03
1394	1.256	24.70	61.39	1.26	3.15	8.31	0.03	34.17	53.08
1406	1.262	25.00	60.22	1.24	3.19	7.76	0.03	33.61	54.17
1419	1.269	26.39	56.80	1.29	3.25	7.80	0.03	33.38	54.26
1431	1.274	28.08	52.37	1.36	3.27	7.98	0.03	32.66	54.71
1444	1.279	30.65	45.27	1.28	3.23	8.78	0.06	32.27	54.38
1456	1.283	28.43	51.28	1.29	3.19	8.58	0.06	31.82	55.06
1469	1.289	25.98	58.34	1.33	3.07	8.92	0.06	31.72	54.90
1481	1.296	22.94	67.30	1.29	3.04	8.62	0.06	32.61	54.38
1494	1.303	22.27	69.83	1.27	3.01	7.96	0.07	32.10	55.58
1506	1.310	24.64	62.95	1.28	2.96	7.60	0.01	31.17	56.97
1519	1.316	26.06	58.00	1.34	3.03	7.42	0.01	30.48	57.71
1531	1.321	28.90	49.54	1.40	3.16	7.56	0.01	29.85	58.03
1544	1.327	29.93	47.49	1.50	3.18	7.74	0.01	28.63	58.94
1556	1.331	31.59	43.38	1.49	3.14	7.65	0.12	29.22	58.38

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. Al Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(M)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
1569	1.336	29.37	49.48	1.57	3.19	7.62	0.12	29.06	58.45
1581	1.341	27.19	54.44	1.55	3.15	7.76	0.28	29.91	57.35
1594	1.347	24.63	61.46	1.46	3.11	7.56	0.39	30.59	56.88
1606	1.353	24.80	60.87	1.36	3.22	7.84	0.90	31.14	55.54
1619	1.360	27.81	54.50	1.37	3.25	8.09	1.00	31.14	55.15
1631	1.365	28.82	51.26	1.41	3.27	8.12	1.00	31.25	54.96
1644	1.370	30.30	47.06	1.45	3.31	8.03	1.20	30.51	55.49
1656	1.375	29.55	48.31	1.42	3.31	8.28	1.09	30.57	55.32
1669	1.380	28.69	51.02	1.62	3.20	8.00	0.87	30.83	55.49
1681	1.385	26.97	56.07	1.59	3.18	8.10	0.76	30.58	55.79
1694	1.392	24.50	61.78	1.55	3.24	8.46	0.76	30.57	55.42
1707	1.398	28.28	52.80	1.70	3.30	8.58	0.57	32.05	53.80
1719	1.403	30.11	47.47	1.77	3.27	8.27	1.46	31.86	53.36
1732	1.407	29.80	48.43	1.71	3.25	8.49	1.18	31.89	53.48
1744	1.412	28.68	50.44	1.71	3.27	8.50	1.07	32.29	53.16
1757	1.418	28.06	51.98	1.84	3.26	8.20	1.07	33.47	52.16
1770	1.423	29.68	47.65	1.64	3.21	8.68	0.89	32.34	53.24
1782	1.428	31.63	44.40	1.68	3.23	9.05	0.64	31.79	53.60
1795	1.432	33.79	39.71	1.64	3.30	9.07	0.64	31.12	54.23
1807	1.436	35.90	35.82	1.67	3.28	9.12	0.74	31.35	53.84
1820	1.440	33.25	40.56	1.50	3.23	9.25	0.86	29.49	55.66
1833	1.444	34.21	39.00	1.58	3.30	9.10	0.90	30.58	54.54
1846	1.449	32.42	42.20	1.55	3.32	9.42	0.25	31.88	53.58
1858	1.452	32.37	42.32	1.54	3.29	9.65	0.25	32.80	52.47
1871	1.457	30.53	45.53	1.57	3.31	9.43	0.16	32.76	52.77
1883	1.462	29.87	47.03	1.69	3.50	10.03	0.03	31.36	53.38
1896	1.467	35.00	39.32	1.74	3.55	10.36	0.08	28.36	55.91
1909	1.471	38.58	33.84	1.74	3.53	9.93	0.21	28.34	56.24
1921	1.473	38.60	33.79	1.74	3.55	10.14	0.52	27.39	56.66
1934	1.477	37.44	35.03	1.62	3.56	10.72	0.52	27.82	55.76
2043	1.512	34.19	39.85	1.66	3.40	10.47	0.52	29.13	54.81
2055	1.516	38.86	32.32	1.57	3.33	10.65	0.43	30.40	53.62
2067	1.519	39.43	31.69	1.60	3.44	11.23	0.49	29.05	54.18
2078	1.521	43.76	25.73	1.43	3.40	11.38	0.19	30.13	53.47
2089	1.524	40.23	30.82	1.62	3.42	11.31	0.19	29.77	53.69
2100	1.527	37.55	34.34	1.39	3.41	11.68	0.36	29.93	53.23
2111	1.530	36.84	35.08	1.53	3.42	11.39	0.36	30.39	52.92

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. Al Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(M)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
2123	1.533	40.87	29.46	1.55	3.36	11.23	0.17	31.61	52.09
2134	1.536	40.79	29.59	1.73	3.46	10.65	0.17	32.41	51.58
2145	1.538	39.17	31.57	1.45	3.52	10.77	0.17	31.48	52.61
2156	1.541	39.63	31.11	1.58	3.59	10.69	0.00	31.89	52.26
2168	1.544	43.52	26.33	1.50	3.69	11.04	0.02	32.69	51.06
2179	1.546	47.26	22.36	1.44	3.70	11.34	0.02	31.65	51.85
2190	1.548	47.09	22.53	1.67	3.70	11.26	0.02	30.16	53.18
2201	1.550	47.39	22.25	1.89	3.71	11.53	0.02	30.15	52.71
2213	1.553	46.86	22.70	1.96	3.64	11.70	0.02	29.79	52.89
2224	1.555	47.89	21.77	1.99	3.53	11.80	0.00	28.99	53.69
2235	1.557	47.72	21.91	2.15	3.63	11.94	0.00	29.21	53.07
2247	1.559	48.32	21.41	1.86	3.57	12.46	0.00	30.29	51.82
2258	1.561	45.50	24.34	1.97	3.58	12.25	0.00	30.50	51.70
2269	1.563	46.15	23.77	2.00	3.62	12.28	0.06	30.28	51.77
2281	1.565	46.03	23.86	1.91	3.78	11.78	0.06	31.25	51.23
2292	1.567	50.42	19.72	1.87	3.74	11.64	0.06	31.07	51.63
2303	1.569	50.88	19.34	2.01	3.78	11.76	0.32	29.37	52.76
2315	1.571	51.28	19.02	1.89	3.82	12.05	0.32	29.29	52.63
2326	1.573	50.85	19.34	1.92	3.85	11.95	0.26	29.54	52.48
2337	1.574	51.13	19.12	2.04	3.65	12.23	0.26	28.86	52.96
2349	1.576	51.37	18.93	2.11	3.69	12.08	0.26	28.94	52.91
2360	1.578	51.66	18.72	2.08	3.60	11.61	0.00	30.14	52.56
2371	1.580	48.37	21.83	2.09	3.61	11.62	0.00	29.95	52.73
2383	1.582	49.34	21.13	1.98	3.63	12.03	0.00	29.93	52.44
2394	1.584	49.68	20.89	2.00	3.76	12.70	0.00	30.06	51.48
2405	1.585	54.12	16.95	1.92	3.61	12.45	0.00	31.66	50.36
2417	1.587	50.40	20.16	1.89	3.72	13.51	0.00	30.60	50.27
2428	1.589	50.32	20.22	1.84	3.61	13.09	0.00	31.98	49.47
2440	1.591	46.59	23.36	1.92	3.64	13.09	0.06	32.13	49.16
2451	1.593	51.04	19.67	1.81	3.58	12.64	0.23	32.62	49.12
2462	1.595	47.93	22.32	1.87	3.74	13.50	0.40	30.81	49.67
2474	1.597	51.79	19.09	1.85	3.83	13.27	0.40	30.97	49.67
2485	1.599	52.39	18.73	1.88	3.85	13.35	0.40	29.40	51.11
2497	1.600	56.75	15.26	1.69	3.86	13.19	0.42	28.97	51.88
2508	1.602	57.60	14.73	1.85	3.93	13.07	0.25	27.27	53.63
2520	1.603	58.04	14.47	1.68	3.90	13.11	0.08	27.86	53.37
2531	1.605	58.88	13.98	1.89	3.95	13.05	0.08	27.75	53.27

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	**Est. Al Conc.**	**CO_2 and CO**	**Total Offgas Flow**	**H_2**	**NO_2**	**N_2**	**O_2**	**N_2O**	**NO**
(sec)	**(M)**	**(vol %)**	**(cm^3/min)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**	**(vol %)**
2542	1.606	59.91	13.39	1.88	4.03	13.63	0.08	27.82	52.56
2554	1.607	60.50	13.06	1.98	3.98	13.75	0.38	27.58	52.34
2565	1.608	60.86	12.86	1.75	4.02	14.01	0.43	27.67	52.13
2577	1.610	61.55	12.50	1.59	4.10	13.84	0.43	27.05	52.98
2588	1.611	61.80	12.37	1.54	4.13	14.41	0.77	27.27	51.88
2600	1.612	62.70	11.90	1.52	4.22	14.21	1.06	26.97	52.02
2611	1.613	63.00	11.75	1.51	4.44	14.24	0.68	28.68	50.45

Appendix F. Raman Offgas Data for Experiment 109-Phase 2

As discussed in Appendix D, the Raman readings should be positive and sum to 100% except in cases where there is significant Ar present. Due to the noise in the Raman signal, any raw readings that are less than zero are fixed to zero and then all the gas readings for H_2, NO_2, N_2, O_2, N_2O, and NO are normalized to 100 vol %. Even with these corrections, the Raman readings have noise in them. To reduce this noise, moving averages of the fixed and normalized readings were performed using equation E-1.

These moving averages do not eliminate all the noise but smooth the values so comparisons and calculations can be performed. The fixed, normalized, and moving average Raman gas concentrations are reported in Table F-1 for Experiment 109-Phase 2. Due to rounding to the nearest hundredth, the numbers in the table may not sum to exactly 100 vol % but all the decimal places were carried in the calculations performed for this report. Note that the starting solution for this experiment had about 4.3 g U/L, 1.6M Al, and 1.4M HNO_3.

Table F-1. Fixed Normalized Moving Average Raman Data for Experiment 109-Phase 2

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
8	4.277	96.59	0.71	3.04	2.74	42.84	10.81	19.60	20.96
20	4.281	96.27	0.78	2.58	2.95	46.11	13.78	27.80	6.77
32	4.283	96.07	0.82	2.46	2.53	42.13	15.90	30.81	6.17
43	4.286	96.18	0.80	1.66	2.59	38.19	22.65	28.87	6.04
55	4.290	95.40	0.96	1.82	2.91	45.20	20.31	27.03	2.73
67	4.294	95.86	0.87	2.24	2.68	43.16	22.86	21.31	7.75
78	4.297	95.48	0.95	2.24	2.67	46.38	23.20	11.88	13.64
90	4.300	95.40	0.97	1.64	3.08	51.05	21.72	8.87	13.64
102	4.305	95.59	0.93	8.53	2.94	48.30	17.44	9.53	13.26
114	4.308	94.58	1.16	7.98	2.72	46.61	19.71	7.54	15.44
126	4.313	94.34	1.21	8.17	2.91	48.77	18.26	11.47	10.42
137	4.318	93.37	1.42	8.43	3.35	47.18	17.76	16.69	6.59
149	4.323	94.16	1.24	8.98	3.35	44.94	16.39	19.76	6.59
161	4.328	94.36	1.20	2.73	3.72	51.51	14.62	20.83	6.59
173	4.333	94.24	1.22	2.80	3.96	53.25	14.12	20.93	4.94
184	4.337	93.90	1.30	2.88	3.99	53.38	10.53	23.01	6.22
196	4.342	93.12	1.48	2.62	3.84	55.80	7.61	17.79	12.34
208	4.349	92.26	1.68	2.07	3.55	53.61	7.88	17.43	15.46
220	4.356	91.44	1.87	0.76	3.43	53.25	9.27	16.01	17.29
232	4.363	90.48	2.11	0.81	3.22	54.85	8.84	16.06	16.22
244	4.372	89.86	2.26	0.13	3.12	55.50	10.30	14.37	16.59
255	4.381	89.04	2.46	0.13	3.26	57.72	10.21	18.00	10.69
267	4.391	89.47	2.36	0.21	3.23	61.65	6.80	17.48	10.64

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
279	4.400	89.46	2.36	0.21	3.35	63.70	4.67	19.25	8.82
291	4.409	90.08	2.20	0.07	3.34	62.39	4.49	18.71	11.00
303	4.418	88.30	2.66	0.19	3.32	66.25	2.19	16.84	11.22
314	4.428	87.65	2.83	0.19	3.19	67.90	3.09	16.61	9.01
326	4.440	86.75	3.06	0.12	3.14	67.32	4.49	18.37	6.56
338	4.452	87.38	2.89	0.15	3.05	67.33	5.06	17.25	7.17
350	4.463	86.94	3.00	0.15	3.08	68.53	3.42	17.04	7.78
362	4.475	85.65	3.36	0.09	3.11	67.88	4.65	16.23	8.04
374	4.489	85.28	3.46	0.09	3.16	69.62	3.24	14.82	9.06
386	4.503	85.64	3.36	0.20	3.30	71.64	1.84	13.47	9.55
398	4.515	86.51	3.12	0.16	3.27	72.35	1.28	11.92	11.01
410	4.528	86.20	3.20	0.16	3.28	74.67	1.23	11.05	9.61
421	4.540	85.28	3.45	0.11	3.25	74.46	0.76	10.83	10.60
433	4.554	84.64	3.63	0.33	3.05	72.05	1.45	11.14	11.99
445	4.568	83.71	3.90	0.22	2.94	70.47	2.20	10.03	14.14
457	4.584	83.00	4.10	0.22	2.90	72.25	2.20	9.14	13.29
469	4.601	83.29	4.02	0.22	2.91	72.13	2.20	9.23	13.31
481	4.616	83.18	4.05	0.25	2.86	70.89	2.04	10.49	13.48
493	4.632	82.65	4.21	0.08	2.93	71.22	2.67	10.66	12.45
505	4.650	81.41	4.57	0.08	2.93	70.85	2.81	10.13	13.20
517	4.668	81.05	4.68	0.13	3.00	70.48	2.81	10.59	12.99
529	4.687	81.73	4.47	0.34	2.99	69.92	4.10	10.07	12.57
541	4.704	81.30	4.60	0.31	3.02	71.09	3.49	9.64	12.46
553	4.722	81.25	4.62	0.26	3.02	72.62	2.99	9.22	11.89
565	4.741	80.58	4.82	0.50	2.95	72.09	3.34	10.71	10.41
577	4.760	80.12	4.97	0.45	2.73	66.52	8.59	9.82	11.90
589	4.780	78.21	5.60	0.25	2.82	67.52	8.13	9.58	11.70
601	4.804	78.02	5.66	0.26	2.85	68.98	8.48	9.72	9.71
613	4.827	78.87	5.39	0.26	2.88	68.36	8.17	9.21	11.12
625	4.845	80.82	4.75	0.01	2.89	71.05	7.54	8.75	9.76
637	4.864	80.77	4.76	0.01	3.01	75.06	2.90	8.89	10.12
649	4.883	80.13	4.96	0.27	2.86	73.68	3.14	9.60	10.44
661	4.903	79.14	5.28	0.26	2.84	72.56	2.85	9.17	12.32
673	4.924	79.05	5.30	0.26	2.80	71.51	2.33	10.03	13.07
685	4.945	78.77	5.39	0.26	2.81	71.17	1.74	9.54	14.48
697	4.966	79.63	5.12	0.26	2.87	71.46	1.12	9.24	15.04
709	4.986	79.62	5.12	0.00	2.92	72.36	0.64	8.20	15.87

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
721	5.006	79.82	5.06	0.00	2.99	73.28	0.75	8.49	14.49
733	5.026	79.67	5.10	0.00	3.02	75.19	1.33	7.57	12.89
745	5.047	79.47	5.17	0.00	3.07	74.10	2.27	8.29	12.28
758	5.068	79.32	5.22	0.00	3.05	74.17	2.64	8.32	11.82
770	5.090	78.93	5.34	0.00	2.94	77.51	2.06	8.56	8.93
782	5.111	77.40	5.86	0.00	2.90	76.93	2.53	8.85	8.79
794	5.135	77.56	5.81	0.01	2.90	75.47	3.37	9.19	9.05
806	5.159	77.47	5.83	0.01	2.94	76.76	3.27	8.45	8.58
818	5.180	79.35	5.21	0.01	2.97	76.38	3.54	8.62	8.48
830	5.200	79.43	5.18	0.01	3.18	73.35	4.20	8.73	10.53
842	5.220	79.04	5.31	0.01	3.30	75.38	4.18	7.14	9.99
854	5.242	79.61	5.14	0.18	3.36	76.54	3.09	5.54	11.29
867	5.264	80.10	4.98	0.40	3.33	73.88	2.81	5.91	13.67
879	5.282	80.27	4.93	0.40	3.31	73.28	4.19	5.32	13.50
891	5.302	79.37	5.20	0.56	3.29	73.45	4.20	4.60	13.91
903	5.324	78.87	5.36	0.56	3.19	70.70	5.23	4.68	15.64
915	5.344	79.41	5.19	0.38	3.16	69.94	6.15	4.85	15.53
927	5.364	79.44	5.18	0.16	3.23	71.79	5.93	3.40	15.49
939	5.385	79.59	5.13	0.16	3.22	72.89	4.41	4.08	15.23
951	5.405	79.95	5.02	0.06	3.22	71.72	4.83	4.43	15.74
964	5.426	80.03	4.99	0.09	3.22	71.79	4.00	4.30	16.61
976	5.446	80.03	4.99	0.09	3.36	74.01	3.00	5.01	14.54
988	5.466	80.39	4.88	0.12	3.35	74.09	2.66	5.45	14.33
1000	5.485	80.59	4.82	0.12	3.51	74.14	2.57	5.44	14.22
1012	5.503	81.04	4.68	0.06	3.48	75.23	1.73	5.79	13.72
1025	5.524	79.85	5.05	0.08	3.53	74.55	1.48	6.05	14.31
1037	5.544	79.60	5.13	0.08	3.41	72.68	1.24	5.86	16.73
1049	5.565	79.09	5.29	0.16	3.47	71.04	1.52	6.03	17.78
1061	5.585	79.82	5.06	0.22	3.41	70.57	1.10	5.56	19.15
1073	5.605	79.88	5.04	0.22	3.52	71.36	0.86	4.37	19.67
1086	5.626	80.65	4.80	0.18	3.61	71.86	1.19	4.69	18.47
1098	5.645	80.79	4.76	0.18	3.67	71.60	1.57	4.23	18.75
1110	5.663	80.96	4.71	0.06	3.71	72.23	1.64	4.57	17.79
1122	5.682	80.22	4.93	0.00	3.81	72.81	3.39	4.28	15.70
1134	5.702	80.19	4.94	0.04	3.93	70.84	3.39	5.63	16.17
1147	5.723	80.49	4.85	0.04	3.92	68.77	3.42	6.71	17.14
1159	5.742	80.46	4.86	0.04	4.18	69.25	3.04	7.18	16.30

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
1171	5.761	81.30	4.61	0.04	4.29	66.76	3.30	7.42	18.19
1184	5.781	80.73	4.79	0.04	4.39	64.29	2.39	8.16	20.71
1196	5.799	81.45	4.56	0.00	4.33	63.68	2.50	7.86	21.63
1208	5.818	79.83	5.06	0.00	4.38	63.63	2.21	6.46	23.32
1221	5.839	79.74	5.09	0.00	4.26	60.64	2.60	6.98	25.52
1233	5.861	79.22	5.25	0.00	4.27	61.56	2.03	6.72	25.42
1245	5.881	79.80	5.06	0.00	4.21	60.19	1.19	6.21	28.21
1257	5.900	79.85	5.05	0.00	4.52	59.37	1.08	5.40	29.63
1270	5.922	80.67	4.80	0.00	4.70	59.88	0.44	4.82	30.16
1282	5.941	81.20	4.64	0.02	4.96	62.01	0.05	4.53	28.43
1294	5.958	82.40	4.27	0.02	5.06	60.83	0.00	3.97	30.12
1307	5.976	81.36	4.59	0.02	5.32	61.49	0.13	4.12	28.91
1319	5.995	81.59	4.52	0.02	5.30	61.55	0.32	4.43	28.39
1331	6.013	81.01	4.69	0.02	5.28	59.06	1.67	4.52	29.45
1344	6.032	81.04	4.68	0.00	5.21	55.32	1.97	5.04	32.46
1356	6.052	80.68	4.79	0.00	5.29	54.38	2.87	5.10	32.36
1368	6.071	80.45	4.86	0.00	5.32	54.36	2.82	5.63	31.86
1381	6.091	80.90	4.72	0.00	5.33	51.61	2.63	6.54	33.89
1393	6.110	80.58	4.82	0.00	5.68	54.08	1.41	6.31	32.52
1405	6.129	81.41	4.57	0.02	5.67	53.19	1.11	6.60	33.40
1418	6.148	80.77	4.77	0.02	5.64	51.74	0.63	9.31	32.66
1430	6.167	79.90	5.05	0.02	5.71	49.62	0.55	8.27	35.84
1443	6.190	79.49	5.17	0.11	6.00	52.35	0.55	7.77	33.22
1455	6.210	80.95	4.73	0.11	5.96	50.39	0.41	9.10	34.03
1467	6.227	82.26	4.32	0.09	6.45	49.64	2.06	8.46	33.31
1480	6.245	83.10	4.07	0.09	6.87	49.12	1.64	6.78	35.49
1492	6.261	82.88	4.14	0.13	7.06	48.10	2.04	7.78	34.88
1505	6.278	83.00	4.10	0.04	7.01	45.16	2.13	7.26	38.41
1517	6.295	82.01	4.39	0.04	7.14	43.25	2.13	7.22	40.23
1529	6.313	81.82	4.45	0.04	6.87	41.31	1.46	6.87	43.46
1542	6.332	81.18	4.64	0.04	6.73	40.73	2.51	5.46	44.54
1554	6.350	81.05	4.68	0.00	6.88	39.76	2.11	5.85	45.40
1567	6.371	81.38	4.58	0.00	7.10	40.24	2.53	6.51	43.62
1579	6.389	82.39	4.28	0.00	7.17	36.47	2.62	5.36	48.37
1591	6.404	83.06	4.08	0.00	7.41	36.48	2.99	5.66	47.47
1604	6.422	82.88	4.13	0.00	7.74	35.97	2.25	5.81	48.23
1616	6.438	82.88	4.13	0.00	7.83	36.76	2.25	6.05	47.10

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
1629	6.456	82.81	4.15	0.00	7.75	35.43	1.75	6.39	48.68
1641	6.472	82.31	4.30	0.00	7.57	38.89	2.49	7.50	43.55
1654	6.491	81.16	4.65	0.00	7.71	39.11	1.16	7.53	44.49
1666	6.510	81.43	4.57	0.00	7.32	40.39	0.84	7.82	43.63
1679	6.530	80.89	4.74	0.00	7.01	37.48	0.84	6.93	47.74
1691	6.548	81.22	4.63	0.00	6.89	37.44	0.84	7.01	47.82
1704	6.569	80.54	4.83	0.00	6.86	34.99	1.04	6.96	50.16
1716	6.588	80.34	4.90	0.00	6.68	34.15	2.54	6.24	50.38
1729	6.609	80.68	4.80	0.00	6.98	31.89	2.55	6.94	51.64
1741	6.628	80.79	4.76	0.00	7.63	33.78	2.55	6.19	49.85
1754	6.647	83.02	4.10	0.00	7.81	30.79	2.55	6.25	52.60
1766	6.663	83.06	4.09	0.05	8.02	31.17	2.00	6.04	52.74
1779	6.679	82.88	4.15	0.05	8.01	30.13	0.49	7.49	53.83
1792	6.699	81.49	4.54	0.05	8.00	30.33	0.65	7.54	53.43
1804	6.717	81.60	4.51	0.05	7.66	28.67	0.87	9.29	53.47
1817	6.736	82.14	4.35	0.05	7.85	27.79	0.87	8.87	54.58
1829	6.753	82.57	4.22	0.00	7.81	28.31	0.38	9.31	54.19
1842	6.770	82.13	4.35	0.00	7.71	28.33	1.08	8.49	54.39
1854	6.788	81.18	4.64	0.00	7.96	29.12	0.92	7.32	54.68
1867	6.809	81.25	4.62	0.00	7.88	28.13	3.05	5.97	54.97
1880	6.828	81.33	4.60	0.00	7.59	28.93	4.00	5.91	53.56
1892	6.846	81.43	4.57	0.00	7.56	27.24	4.00	5.37	55.83
1905	6.866	80.50	4.85	0.00	7.67	26.93	4.38	4.90	56.12
1917	6.886	80.42	4.87	0.00	7.69	25.45	4.38	4.77	57.72
1930	6.906	81.84	4.45	0.00	7.63	25.15	3.75	4.32	59.14
1942	6.923	82.17	4.35	0.00	7.89	24.86	2.81	4.64	59.81
1955	6.941	82.76	4.17	0.00	8.04	23.69	2.81	4.39	61.07
1968	6.959	81.51	4.54	0.00	8.20	24.05	1.73	3.98	62.03
1980	6.977	81.71	4.48	0.00	8.05	24.30	1.73	4.06	61.86
1993	6.997	81.56	4.52	0.00	8.25	24.69	0.50	4.99	61.56
2006	7.016	82.19	4.34	0.00	8.16	25.76	0.91	5.81	59.36
2018	7.033	81.94	4.41	0.00	7.95	28.53	0.91	5.94	56.67
2031	7.052	80.80	4.76	0.00	7.81	28.41	0.91	6.64	56.24
2044	7.073	80.13	4.96	0.00	7.76	28.77	0.91	7.99	54.57
2056	7.093	80.26	4.92	0.00	7.54	29.07	0.41	8.97	54.01
2069	7.113	81.52	4.54	0.00	7.46	28.75	0.00	8.67	55.11
2082	7.132	81.57	4.52	0.00	7.79	28.17	0.57	9.53	53.94

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
2094	7.150	81.57	4.52	0.00	7.70	27.21	0.57	9.90	54.62
2107	7.170	80.48	4.85	0.00	7.50	24.95	0.70	9.71	57.14
2230	7.367	80.02	5.00	0.28	7.34	23.87	0.83	8.67	59.00
2242	7.388	78.96	5.33	0.28	7.27	22.82	0.83	6.69	62.10
2253	7.407	79.15	5.27	0.28	7.01	21.47	2.03	4.97	64.23
2264	7.426	78.99	5.32	0.28	6.99	21.02	3.46	4.12	64.14
2275	7.445	79.16	5.27	0.28	6.86	21.18	4.28	3.05	64.34
2286	7.465	78.49	5.48	0.00	7.21	20.83	4.16	2.92	64.88
2298	7.486	79.47	5.18	0.00	7.12	19.54	4.66	4.40	64.27
2309	7.505	79.23	5.26	0.00	7.16	19.29	3.36	5.51	64.67
2320	7.523	79.98	5.02	0.00	7.16	20.77	1.94	5.81	64.33
2331	7.542	78.97	5.33	0.00	7.37	21.36	0.99	6.29	64.00
2343	7.563	79.38	5.20	0.00	7.00	20.73	2.20	7.25	62.82
2354	7.582	78.28	5.55	0.00	6.94	21.42	2.60	6.92	62.12
2365	7.602	78.11	5.61	0.00	6.81	21.84	2.12	6.58	62.65
2376	7.623	77.31	5.87	0.00	6.64	21.08	2.12	6.91	63.25
2388	7.646	77.25	5.89	0.00	6.59	21.36	3.00	6.85	62.20
2399	7.668	77.89	5.69	0.00	6.61	22.40	1.77	6.10	63.12
2410	7.688	78.29	5.55	0.00	6.69	23.65	0.88	5.78	63.00
2422	7.709	79.01	5.31	0.00	6.96	25.08	0.88	4.71	62.38
2433	7.729	79.37	5.21	0.00	6.96	25.39	0.88	4.98	61.79
2444	7.747	78.60	5.46	0.00	6.76	25.18	1.61	5.21	61.23
2456	7.768	77.75	5.75	0.00	6.63	23.86	1.61	5.37	62.52
2467	7.791	76.78	6.05	0.00	6.77	23.42	1.61	6.53	61.67
2478	7.813	78.12	5.61	0.00	6.63	22.19	1.61	8.08	61.49
2490	7.833	79.17	5.26	0.00	6.91	22.25	2.59	7.91	60.34
2501	7.852	79.49	5.16	0.00	7.17	23.09	0.98	8.63	60.13
2512	7.871	79.89	5.04	0.00	7.29	24.89	0.98	7.67	59.17
2524	7.890	79.37	5.21	0.00	7.09	24.22	0.98	6.40	61.32
2535	7.909	78.64	5.44	0.10	7.05	23.31	1.40	5.98	62.15
2546	7.930	77.85	5.69	0.10	6.83	22.29	0.93	5.83	64.01
2558	7.953	77.31	5.87	0.10	6.62	20.55	1.05	5.58	66.11
2569	7.974	77.35	5.86	0.10	6.60	20.45	1.27	6.08	65.51
2581	7.998	76.73	6.07	0.10	6.53	20.71	1.27	6.21	65.19
2592	8.019	77.30	5.87	0.00	6.53	21.02	1.13	6.43	64.89
2603	8.041	77.32	5.87	0.00	6.94	22.30	1.39	6.69	62.67
2615	8.063	78.82	5.39	0.00	6.98	22.47	2.44	6.44	61.68

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
2626	8.082	78.64	5.45	0.00	7.23	22.65	3.07	6.43	60.62
2637	8.101	79.71	5.10	0.00	7.62	24.11	3.07	6.35	58.85
2649	8.122	79.58	5.14	0.06	7.54	24.36	3.04	6.26	58.74
2660	8.140	79.51	5.16	0.06	6.99	23.72	2.88	5.82	60.54
2672	8.161	77.54	5.82	0.06	7.10	24.36	1.72	5.83	60.93
2683	8.184	76.75	6.07	0.06	6.79	24.33	0.94	5.68	62.21
2695	8.208	76.58	6.13	0.06	6.51	23.35	0.94	5.72	63.42
2706	8.229	77.59	5.78	0.00	6.57	24.08	0.68	6.08	62.59
2717	8.250	77.70	5.74	0.00	6.82	24.51	0.07	6.26	62.34
2729	8.272	78.31	5.54	0.00	6.60	24.09	0.07	5.84	63.40
2740	8.292	77.93	5.67	0.00	6.70	23.76	0.07	5.87	63.61
2752	8.315	77.59	5.78	0.00	6.72	23.58	0.57	6.31	62.82
2763	8.336	77.47	5.82	0.00	6.52	22.80	1.30	5.21	64.17
2775	8.359	77.01	5.98	0.00	6.41	22.23	1.30	5.66	64.40
2786	8.381	76.76	6.06	0.00	6.44	22.23	3.19	6.11	62.04
2798	8.406	76.14	6.27	0.00	6.24	22.21	3.12	6.17	62.25
2809	8.428	76.70	6.08	0.00	6.28	22.92	2.62	5.55	62.63
2821	8.452	77.17	5.92	0.00	6.37	22.39	2.18	7.29	61.78
2832	8.473	76.90	6.01	0.00	6.39	22.06	2.68	7.24	61.63
2844	8.496	76.71	6.08	0.00	6.58	22.39	0.79	6.36	63.89
2855	8.519	76.64	6.10	0.00	6.84	23.18	0.90	6.75	62.34
2867	8.543	77.46	5.82	0.00	6.72	22.71	0.90	6.36	63.30
2878	8.563	77.83	5.70	0.00	6.57	21.52	1.39	9.03	61.50
2890	8.586	74.67	6.87	0.00	6.74	21.35	2.25	8.56	61.09
2901	8.613	74.73	6.85	0.00	6.55	21.26	2.25	8.99	60.94
2913	8.642	74.29	7.00	0.00	6.32	19.55	2.14	8.49	63.50
2924	8.663	76.79	6.05	0.00	6.30	19.29	2.14	9.72	62.56
2936	8.688	76.69	6.08	0.00	6.28	20.91	1.37	6.37	65.07
2948	8.711	76.58	6.12	0.00	6.05	20.60	0.19	6.27	66.89
2959	8.733	76.97	5.99	0.00	6.07	19.47	1.46	5.61	67.39
2971	8.758	76.30	6.21	0.00	6.09	19.49	1.46	6.34	66.62
2982	8.780	76.27	6.23	0.00	6.06	19.07	1.46	6.22	67.19
2994	8.805	75.60	6.46	0.00	6.18	18.35	1.46	6.09	67.92
3005	8.829	75.46	6.51	0.00	6.17	19.01	1.28	5.76	67.79
3017	8.854	75.62	6.45	0.00	5.95	19.24	0.78	7.41	66.63
3029	8.880	75.01	6.67	0.00	5.92	19.83	1.21	7.52	65.52
3040	8.904	74.63	6.80	0.00	5.89	19.99	1.21	7.55	65.36

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
3052	8.932	74.27	6.93	0.00	5.85	21.14	1.48	6.91	64.62
3063	8.956	74.67	6.78	0.00	5.78	20.64	1.48	7.58	64.53
3075	8.983	75.24	6.58	0.00	5.80	21.29	0.70	6.85	65.36
3087	9.009	75.12	6.63	0.00	5.96	21.73	0.27	5.74	66.30
3098	9.032	75.98	6.33	0.00	6.07	23.18	0.27	5.81	64.67
3110	9.057	76.56	6.13	0.00	6.02	22.68	0.08	6.00	65.23
3122	9.080	76.68	6.09	0.00	6.31	22.61	0.11	6.56	64.41
3133	9.103	76.97	5.99	0.00	6.76	22.23	0.11	7.34	63.56
3145	9.127	77.33	5.88	0.00	6.47	21.65	0.11	8.54	63.23
3157	9.148	76.67	6.12	0.00	6.21	19.80	0.11	8.31	65.56
3168	9.172	75.01	6.70	0.00	6.36	19.78	0.03	8.35	65.48
3180	9.201	74.17	6.98	0.00	6.15	20.36	0.00	8.17	65.31
3192	9.227	75.00	6.67	0.00	5.75	20.35	0.00	7.48	66.42
3204	9.252	75.23	6.59	0.00	6.02	20.55	0.07	6.08	67.28
3215	9.277	75.60	6.46	0.00	6.17	21.05	0.12	5.99	66.67
3227	9.302	75.53	6.49	0.00	5.99	20.81	0.12	6.31	66.76
3239	9.327	75.37	6.55	0.00	5.92	20.12	0.33	5.22	68.40
3251	9.354	74.51	6.84	0.00	5.87	20.40	1.47	4.34	67.93
3263	9.381	73.56	7.19	0.00	5.90	19.89	1.80	4.93	67.48
3274	9.407	74.37	6.90	0.00	5.89	18.83	1.75	4.79	68.74
3286	9.435	74.41	6.89	0.00	5.86	18.68	1.75	4.79	68.93
3298	9.461	75.05	6.65	0.00	5.83	19.08	2.40	5.17	67.53
3310	9.488	74.26	6.93	0.00	5.95	19.09	2.03	6.08	66.85
3322	9.515	74.09	6.99	0.00	5.89	19.64	2.74	6.27	65.46
3333	9.541	74.44	6.87	0.00	5.82	19.81	2.93	6.45	64.99
3345	9.567	74.21	6.95	0.00	6.24	20.17	2.93	5.40	65.25
3357	9.595	75.73	6.44	0.00	6.21	20.89	2.50	5.53	64.87
3369	9.620	75.16	6.64	0.00	6.48	20.44	2.25	5.18	65.65
3381	9.645	76.75	6.08	0.00	6.52	20.18	1.13	5.14	67.03
3393	9.670	75.96	6.34	0.00	6.45	20.10	1.85	5.07	66.53
3404	9.692	75.85	6.38	0.00	6.26	19.90	2.78	6.22	64.84
3416	9.718	75.38	6.54	0.00	6.83	15.98	2.92	5.91	68.36
3428	9.745	77.16	5.97	0.00	6.61	15.21	2.92	6.10	69.16
3440	9.766	77.62	5.81	0.00	6.46	14.96	2.92	5.83	69.83
3452	9.788	76.82	6.09	0.00	6.63	15.85	2.02	5.22	70.28
3464	9.815	74.84	6.73	0.00	6.41	15.76	1.09	4.88	71.87
3476	9.842	74.12	6.99	0.00	5.85	18.88	0.51	4.78	69.98

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
3487	9.867	74.26	6.94	0.00	5.83	19.79	0.58	4.41	69.39
3499	9.895	73.77	7.12	0.00	6.02	19.84	1.19	4.22	68.74
3511	9.922	75.42	6.53	0.00	5.86	19.68	1.19	4.58	68.69
3523	9.947	74.92	6.71	0.00	5.92	20.38	1.19	3.95	68.56
3535	9.974	74.73	6.78	0.00	6.08	20.51	1.92	4.73	66.76
3547	10.002	74.30	6.93	0.00	6.05	20.91	1.34	4.86	66.84
3559	10.029	74.85	6.72	0.00	5.90	21.42	0.73	5.59	66.36
3571	10.054	75.38	6.54	0.00	6.02	21.43	1.09	5.64	65.81
3583	10.081	75.17	6.61	0.00	6.15	21.50	1.09	5.20	66.05
3595	10.106	75.82	6.38	0.00	6.10	21.62	0.45	5.16	66.67
3607	10.131	75.91	6.35	0.00	6.06	21.17	0.45	6.33	65.99
3619	10.156	75.01	6.67	0.00	6.07	21.61	0.45	6.43	65.43
3631	10.183	74.37	6.90	0.08	6.15	20.95	0.09	6.52	66.21
3642	10.209	74.61	6.82	0.08	5.95	20.48	0.09	7.40	66.01
3654	10.235	74.66	6.80	0.10	5.80	20.22	0.49	6.69	66.70
3666	10.262	74.19	6.97	0.10	5.79	19.93	0.49	5.93	67.76
3678	10.291	73.49	7.22	0.10	5.74	19.48	0.49	5.95	68.24
3690	10.319	74.10	6.99	0.02	5.63	19.91	0.49	5.63	68.31
3702	10.346	74.80	6.74	0.02	5.64	19.65	0.49	6.17	68.02
3714	10.372	74.39	6.89	0.00	5.73	19.98	0.47	5.89	67.93
3726	10.399	74.35	6.90	0.00	5.83	19.86	0.47	5.98	67.87
3738	10.427	74.13	6.98	0.00	5.91	19.66	0.47	5.54	68.42
3750	10.454	74.95	6.68	0.00	5.86	19.93	0.63	5.60	67.98
3762	10.480	74.78	6.75	0.00	6.06	20.32	0.63	5.77	67.22
3774	10.507	75.27	6.57	0.00	5.97	19.48	0.16	6.42	67.97
3786	10.533	74.50	6.85	0.00	5.88	20.69	0.16	7.62	65.65
3798	10.560	75.13	6.63	0.00	5.91	20.52	0.16	7.55	65.87
3810	10.587	75.25	6.59	0.00	5.98	20.73	0.00	7.60	65.69
3822	10.611	75.61	6.45	0.00	5.73	19.18	0.00	7.64	67.44
3835	10.639	74.20	6.97	0.00	5.77	19.46	0.09	7.99	66.69
3847	10.668	73.38	7.26	0.00	5.87	19.35	0.09	6.64	68.05
3859	10.698	73.68	7.15	0.00	5.75	19.20	0.17	6.86	68.02
3871	10.724	74.25	6.94	0.00	5.72	18.26	0.17	7.34	68.52
3883	10.752	73.88	7.08	0.00	5.98	20.78	0.17	7.26	65.81
3895	10.781	73.90	7.07	0.00	6.02	21.29	0.08	7.42	65.19
3907	10.808	74.01	7.03	0.00	5.97	20.59	0.21	6.82	66.41
3919	10.835	74.56	6.82	0.00	5.93	20.79	0.13	6.57	66.57

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
3931	10.863	73.54	7.20	0.00	5.91	21.94	0.13	5.56	66.46
3943	10.891	73.75	7.12	0.00	5.72	20.65	0.13	4.69	68.80
3955	10.920	73.39	7.26	0.00	5.66	20.20	0.13	4.00	70.01
3967	10.948	73.67	7.15	0.00	5.71	20.14	0.06	4.26	69.84
3979	10.976	73.84	7.09	0.00	5.59	20.46	0.06	7.17	66.71
3992	11.006	71.57	8.02	0.00	5.69	19.98	0.06	8.39	65.87
4004	11.039	71.97	7.87	0.00	5.67	19.60	0.53	8.33	65.87
4016	11.073	71.41	8.07	0.00	5.77	19.65	1.52	8.37	64.69
4028	11.101	73.95	7.05	0.00	5.70	19.67	1.46	8.06	65.12
4040	11.129	73.58	7.18	0.00	5.77	20.00	1.62	4.83	67.78
4053	11.159	73.83	7.09	0.00	5.80	19.43	1.62	4.42	68.72
4065	11.188	74.12	6.99	0.00	5.95	19.06	1.88	4.05	69.05
4077	11.214	74.85	6.72	0.00	5.94	19.42	0.89	4.49	69.26
4089	11.240	74.87	6.71	0.00	5.99	20.24	1.23	5.06	67.49
4101	11.267	74.86	6.72	0.00	6.00	19.22	1.82	4.77	68.19
4113	11.294	74.49	6.85	0.00	5.87	19.18	2.34	4.53	68.08
4126	11.323	74.36	6.90	0.00	5.71	19.32	2.63	5.48	66.87
4138	11.351	73.43	7.24	0.00	5.96	19.33	4.13	4.10	66.47
4150	11.380	74.19	6.97	0.07	5.89	18.33	4.35	3.52	67.85
4162	11.407	74.11	7.00	0.07	5.77	18.22	4.29	4.55	67.10
4175	11.436	73.29	7.33	0.07	6.10	19.07	4.55	4.69	65.53
4187	11.467	73.59	7.23	0.07	6.05	19.91	3.53	4.64	65.79
4199	11.495	73.76	7.17	0.07	5.79	19.50	2.14	5.90	66.60
4211	11.521	75.10	6.65	0.00	5.76	19.55	2.43	5.75	66.51
4223	11.549	73.55	7.19	0.00	6.00	19.97	1.74	5.18	67.10
4236	11.580	73.85	7.09	0.00	5.73	20.46	1.97	5.66	66.18
4248	11.608	73.93	7.06	0.00	5.80	20.14	1.97	5.23	66.86
4260	11.635	74.02	7.02	0.00	5.18	18.29	1.86	4.63	70.04
4272	11.663	68.68	9.45	0.00	5.21	18.00	1.15	5.37	70.26
4285	11.709	68.45	9.53	0.00	5.09	17.55	1.17	5.87	70.32
4297	11.751	68.51	9.51	0.00	4.97	16.22	0.16	5.36	73.28
4309	11.779	72.90	7.44	0.00	5.22	17.04	0.49	6.02	71.24
4322	11.811	74.26	6.96	0.00	5.69	18.69	0.49	7.30	67.83
4334	11.838	73.92	7.09	0.00	5.64	19.56	0.35	7.38	67.07
4346	11.865	74.56	6.85	0.00	5.62	19.54	0.33	7.81	66.71
4358	11.894	73.56	7.19	0.00	5.77	20.37	0.33	8.01	65.54
4371	11.924	74.61	6.81	0.00	5.71	19.98	0.00	7.93	66.38

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
4383	11.950	75.79	6.40	0.00	5.77	20.09	0.00	7.12	67.01
4395	11.974	75.34	6.56	0.00	5.69	19.27	0.00	6.71	68.33
4408	12.002	74.04	7.04	0.00	5.66	19.37	0.32	5.95	68.70
4420	12.033	72.22	7.70	0.00	5.66	18.91	0.32	5.83	69.28
4432	12.064	72.68	7.53	0.00	5.37	17.89	0.32	5.19	71.23
4445	12.095	73.02	7.40	0.00	5.55	19.68	0.32	4.85	69.61
4457	12.123	74.72	6.78	0.00	5.42	20.38	0.32	5.26	68.62
4469	12.150	74.00	7.05	0.00	5.49	20.26	0.00	5.71	68.55
4482	12.179	74.33	6.92	0.00	5.22	19.83	0.00	7.28	67.68
4494	12.208	71.02	8.21	0.00	5.26	20.94	0.40	7.79	65.60
4506	12.242	71.12	8.17	0.00	5.16	19.13	0.40	8.40	66.91
4519	12.279	71.69	7.96	0.00	5.48	20.05	0.61	8.18	65.69
4531	12.307	74.40	6.89	0.00	5.28	19.97	0.61	8.35	65.80
4543	12.332	73.33	7.31	0.00	5.50	20.36	0.61	5.95	67.57
4556	12.365	73.38	7.30	0.00	5.46	19.73	0.21	6.00	68.60
4568	12.396	72.66	7.56	0.00	5.43	19.88	0.39	5.75	68.55
4581	12.425	74.45	6.87	0.00	5.25	18.76	0.18	5.49	70.32
4593	12.453	73.15	7.35	0.00	5.46	20.64	0.18	4.92	68.80
4605	12.482	73.13	7.36	0.00	5.38	21.13	0.18	5.03	68.28
4618	12.515	72.84	7.46	0.00	5.41	21.07	0.18	4.81	68.53
4630	12.543	73.44	7.23	0.00	5.41	21.20	0.00	4.07	69.33
4643	12.574	74.02	7.02	0.00	5.35	21.69	0.00	4.34	68.62
4655	12.601	73.71	7.14	0.00	5.35	20.05	0.00	4.56	70.03
4667	12.629	74.07	7.00	0.00	5.47	20.14	0.00	5.46	68.93
4680	12.660	74.29	6.93	0.00	5.52	20.49	0.00	6.29	67.71
4693	12.688	74.45	6.87	0.00	5.46	20.74	0.07	7.04	66.69
4705	12.716	73.75	7.13	0.00	5.55	20.93	0.07	7.00	66.45
4717	12.745	73.13	7.35	0.00	5.51	20.95	0.87	6.45	66.22
4730	12.776	73.45	7.23	0.00	5.39	20.14	0.87	5.87	67.73
4742	12.804	74.20	6.96	0.00	5.45	19.35	0.87	4.90	69.44
4755	12.833	74.77	6.75	0.00	5.55	20.11	1.70	5.34	67.30
4767	12.860	75.08	6.64	0.00	5.56	19.29	1.70	5.42	68.03
4780	12.888	74.30	6.93	0.00	5.61	19.41	0.90	6.34	67.74
4792	12.916	74.22	6.95	0.00	5.68	18.81	1.46	7.12	66.93
4805	12.946	73.92	7.06	0.00	5.60	19.09	1.46	6.92	66.92
4817	12.973	74.67	6.79	0.04	5.51	18.05	0.56	5.92	69.91
4830	13.002	74.33	6.91	0.04	5.62	18.51	0.56	6.13	69.14

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
4842	13.030	74.57	6.82	0.04	5.54	17.86	0.60	5.05	70.92
4855	13.059	74.88	6.71	0.04	5.58	17.48	0.03	4.20	72.66
4867	13.085	75.42	6.52	0.04	5.52	18.71	0.91	4.28	70.54
4880	13.112	74.41	6.89	0.00	5.51	18.68	2.45	4.74	68.63
4892	13.140	74.02	7.03	0.00	5.44	18.18	3.64	4.38	68.36
4905	13.172	73.48	7.22	0.00	5.41	18.66	4.10	4.42	67.41
4917	13.199	73.67	7.15	0.01	5.34	21.14	4.71	4.49	64.31
4930	13.230	73.77	7.11	0.01	5.31	21.50	4.29	4.02	64.87
4942	13.259	73.21	7.33	0.01	5.24	21.51	3.14	4.12	65.98
4955	13.289	73.13	7.35	0.01	5.31	21.04	2.56	3.43	67.65
4968	13.322	73.07	7.38	0.08	5.41	20.91	2.07	3.74	67.77
4980	13.351	73.83	7.09	0.07	5.39	19.04	2.37	3.21	69.92
4993	13.380	74.18	6.96	0.07	5.48	16.51	3.80	3.74	70.39
5005	13.407	73.84	7.09	0.07	5.55	15.81	5.11	3.28	70.17
5018	13.438	73.57	7.18	0.07	5.58	15.16	5.64	3.67	69.88
5031	13.469	74.35	6.90	0.00	5.54	15.42	6.56	3.76	68.71
5043	13.496	74.69	6.78	0.00	5.70	16.86	5.72	4.02	67.71
5056	13.524	75.51	6.49	0.00	5.65	17.77	4.62	4.20	67.74
5068	13.550	74.52	6.85	0.00	5.87	17.51	3.00	3.49	70.13
5081	13.579	75.57	6.48	0.00	5.83	18.80	1.87	4.00	69.50
5094	13.607	75.32	6.57	0.00	6.19	18.81	0.94	4.59	69.47
5106	13.631	77.41	5.85	0.00	6.11	17.23	0.88	5.32	70.46
5119	13.656	76.69	6.09	0.00	6.21	17.26	0.57	5.62	70.34
5131	13.680	76.56	6.14	0.00	6.02	18.23	0.48	6.94	68.33
5144	13.708	75.21	6.59	0.00	5.99	18.29	0.87	6.91	67.95
5157	13.736	75.11	6.63	0.00	5.68	18.65	1.01	6.50	68.16
5169	13.762	75.08	6.64	0.00	5.79	20.04	1.01	6.14	67.03
5182	13.791	75.64	6.44	0.00	5.76	19.86	0.53	7.00	66.86
5195	13.818	75.38	6.54	0.00	5.63	19.34	0.53	6.49	68.02
5207	13.843	74.98	6.68	0.00	5.53	19.40	0.14	6.18	68.76
5397	14.280	74.35	6.90	0.00	5.43	18.91	0.00	6.65	69.01
5409	14.307	74.23	6.95	0.00	5.13	17.89	0.24	6.35	70.38
5420	14.332	74.12	6.98	0.00	5.02	17.99	0.24	5.54	71.21
5432	14.360	74.20	6.96	0.00	5.29	19.03	0.68	5.87	69.12
5443	14.385	75.35	6.56	0.00	5.30	18.64	0.68	6.44	68.93
5454	14.408	75.92	6.35	0.00	5.18	19.25	0.68	6.19	68.71
5465	14.430	74.86	6.74	0.00	5.38	19.43	0.73	6.61	67.85

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
5476	14.456	74.62	6.82	0.00	5.43	19.64	1.18	5.93	67.81
5488	14.484	74.63	6.82	0.00	5.41	17.95	0.74	6.36	69.55
5499	14.507	76.37	6.19	0.00	5.36	17.64	0.74	6.87	69.38
5510	14.529	75.44	6.52	0.00	5.57	15.98	0.74	6.65	71.07
5522	14.555	75.77	6.40	0.00	5.49	16.28	0.64	6.69	70.90
5533	14.579	75.12	6.63	0.00	5.45	16.34	1.41	6.72	70.08
5544	14.602	75.30	6.56	0.00	5.23	17.39	1.58	6.94	68.87
5555	14.626	74.51	6.84	0.00	5.44	14.73	2.04	6.56	71.22
5567	14.654	75.27	6.58	0.00	5.35	15.98	2.04	6.64	69.98
5578	14.677	76.10	6.29	0.00	5.35	15.93	2.87	6.82	69.04
5589	14.699	76.56	6.13	0.00	5.43	15.97	1.64	7.49	69.46
5601	14.723	76.03	6.31	0.00	5.61	15.65	1.79	7.03	69.92
5612	14.747	76.02	6.31	0.00	5.70	19.77	1.32	7.16	66.06
5623	14.769	77.15	5.93	0.00	5.77	18.83	1.32	8.27	65.81
5635	14.792	76.90	6.02	0.00	5.96	19.58	0.31	8.01	66.14
5646	14.813	77.47	5.83	0.00	5.89	19.59	1.11	7.71	65.71
5657	14.835	76.19	6.26	0.00	5.86	20.29	0.81	7.68	65.36
5669	14.859	76.84	6.04	0.00	5.70	20.02	0.81	7.05	66.43
5680	14.882	76.86	6.03	0.00	5.66	21.96	0.81	5.44	66.13
5691	14.903	77.13	5.94	0.00	5.48	21.31	0.81	5.00	67.41
5703	14.926	76.85	6.03	0.00	5.48	20.99	0.00	4.57	68.95
5714	14.949	76.05	6.30	0.00	5.55	19.94	0.12	4.38	70.00
5725	14.972	76.69	6.08	0.01	5.42	19.13	0.72	3.90	70.81
5737	14.995	76.32	6.21	0.01	5.37	17.58	1.22	4.30	71.53
5748	15.018	75.77	6.40	0.01	5.56	17.78	1.22	5.39	70.04
5759	15.042	75.96	6.34	0.01	5.65	17.93	1.22	5.95	69.24
5771	15.066	76.51	6.15	0.01	5.54	19.06	1.14	6.09	68.16
5782	15.088	76.67	6.09	0.00	5.66	18.93	0.54	6.41	68.45
5794	15.112	76.22	6.24	0.20	5.74	18.76	0.04	5.95	69.31
5805	15.135	75.99	6.32	0.23	5.63	18.55	0.04	5.53	70.03
5816	15.158	76.57	6.12	0.23	5.64	19.25	0.04	4.78	70.06
5828	15.182	76.64	6.10	0.23	5.82	18.75	0.26	5.39	69.55
5839	15.204	77.36	5.85	0.23	6.01	20.42	1.38	5.54	66.42
5851	15.227	78.31	5.54	0.02	6.10	21.13	1.38	5.98	65.38
5862	15.246	78.35	5.53	0.00	6.12	21.36	1.89	5.71	64.93
5874	15.268	78.32	5.54	0.00	6.18	21.04	2.75	5.90	64.13
5885	15.288	77.67	5.75	0.00	6.10	20.85	2.49	5.33	65.23

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
5897	15.311	78.29	5.55	0.00	5.97	20.24	1.37	5.59	66.82
5908	15.331	78.11	5.60	0.00	5.98	19.59	1.37	5.64	67.42
5919	15.351	78.08	5.62	0.00	6.04	20.05	1.62	5.30	66.99
5931	15.373	78.57	5.46	0.00	6.05	20.49	0.99	6.12	66.35
5942	15.393	79.21	5.25	0.00	6.06	22.43	1.25	5.09	65.17
5954	15.412	79.33	5.22	0.00	6.05	21.62	1.25	5.22	65.86
5965	15.432	78.51	5.48	0.00	5.95	22.26	1.35	4.89	65.55
5977	15.454	77.43	5.83	0.00	5.77	21.06	0.59	5.60	66.97
5988	15.476	76.71	6.08	0.00	5.56	19.92	1.26	4.90	68.36
6000	15.500	75.40	6.53	0.00	5.55	17.48	2.12	5.63	69.23
6011	15.525	75.49	6.50	0.00	5.53	17.56	2.12	4.52	70.27
6023	15.551	76.33	6.22	0.00	5.54	17.36	2.77	4.23	70.10
6034	15.572	77.48	5.81	0.00	5.44	18.44	3.79	3.96	68.37
6046	15.594	76.54	6.15	0.00	5.35	19.20	3.35	4.06	68.04
6057	15.617	75.04	6.67	0.00	5.33	19.74	3.35	4.30	67.28
6069	15.645	74.84	6.73	0.00	5.23	18.98	4.47	4.06	67.25
6081	15.671	75.56	6.48	0.00	5.40	18.88	3.73	4.61	67.38
6092	15.693	77.16	5.93	0.03	5.47	17.93	3.89	4.95	67.74
6104	15.717	76.66	6.10	0.03	5.79	16.99	3.86	4.62	68.70
6115	15.738	77.45	5.83	0.03	5.73	16.86	3.44	5.04	68.90
6127	15.762	76.62	6.11	0.03	5.64	17.17	2.31	6.50	68.35
6138	15.783	76.88	6.02	0.03	5.61	16.68	3.53	6.01	68.13
6150	15.808	77.20	5.92	0.00	5.56	15.93	3.09	5.37	70.05
6161	15.829	76.71	6.09	0.00	5.42	16.37	3.09	5.92	69.19
6173	15.853	76.90	6.02	0.00	5.57	16.86	2.39	5.99	69.20
6185	15.878	76.91	6.02	0.00	5.73	17.35	2.39	5.50	69.04
6196	15.898	77.44	5.83	0.00	5.68	18.35	1.51	6.09	68.36
6208	15.921	78.12	5.61	0.00	5.86	18.72	1.57	6.77	67.08
6219	15.942	77.75	5.73	0.00	5.75	18.92	1.13	7.22	66.97
6231	15.963	78.12	5.60	0.00	5.73	19.12	1.13	7.71	66.31
6243	15.986	78.10	5.61	0.00	5.54	18.57	2.02	8.05	65.83
6254	16.006	76.78	6.07	0.00	5.38	18.00	2.50	8.06	66.06
6266	16.031	76.50	6.16	0.00	5.28	18.72	1.71	7.89	66.41
6278	16.056	75.86	6.37	0.01	5.32	18.16	1.71	7.61	67.20
6289	16.078	76.47	6.16	0.01	5.22	17.69	1.71	6.75	68.63
6301	16.103	76.81	6.04	0.01	5.47	18.08	0.82	6.75	68.86
6313	16.127	77.75	5.73	0.01	5.55	18.19	0.00	6.57	69.68

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
6324	16.146	78.17	5.59	0.01	5.57	18.36	0.00	6.96	69.09
6336	16.168	78.24	5.57	0.00	5.68	18.53	0.00	7.10	68.68
6348	16.191	77.32	5.87	0.00	5.63	18.03	1.06	7.04	68.23
6359	16.212	77.24	5.89	0.00	5.64	18.84	2.33	7.66	65.53
6371	16.236	77.97	5.66	0.00	5.59	18.76	2.66	8.28	64.71
6383	16.257	78.10	5.62	0.00	5.68	18.85	2.66	6.74	66.06
6394	16.277	78.66	5.43	0.00	5.87	19.39	2.66	6.20	65.87
6406	16.299	78.94	5.35	0.00	5.80	19.42	2.76	5.91	66.10
6418	16.319	78.39	5.53	0.00	5.76	18.66	1.72	4.92	68.93
6430	16.341	78.39	5.53	0.00	5.95	19.24	1.38	4.85	68.58
6441	16.363	77.92	5.68	0.00	5.80	18.33	1.80	6.41	67.65
6453	16.384	78.42	5.51	0.01	5.51	17.15	2.26	6.88	68.18
6465	16.406	77.96	5.66	0.01	5.64	17.83	1.20	7.22	68.09
6476	16.427	77.50	5.81	0.01	5.71	16.94	0.98	7.56	68.80
6488	16.450	78.12	5.60	0.01	5.56	16.37	0.98	6.77	70.30
6500	16.471	78.42	5.50	0.01	5.80	16.65	1.88	6.25	69.40
6512	16.493	79.16	5.27	0.00	5.86	17.53	2.25	5.64	68.73
6523	16.512	79.52	5.15	0.00	5.85	17.26	2.34	5.05	69.51
6535	16.531	79.62	5.12	0.00	5.58	17.74	2.34	5.01	69.34
6547	16.552	78.71	5.42	0.00	5.49	17.06	3.49	5.18	68.78
6559	16.574	77.34	5.87	0.00	5.39	16.48	2.17	5.07	70.89
6571	16.598	77.56	5.79	0.00	5.27	15.33	2.92	4.84	71.64
6582	16.619	77.65	5.77	0.00	5.40	14.18	3.75	4.59	72.08
6594	16.640	78.90	5.35	0.00	5.67	14.75	3.75	5.04	70.80
6606	16.662	79.74	5.09	0.00	5.77	14.96	3.06	4.47	71.73
6618	16.681	80.09	4.98	0.00	5.68	15.21	4.15	5.18	69.78
6630	16.700	79.55	5.15	0.00	5.75	15.51	2.57	6.04	70.12
6641	16.720	78.13	5.60	0.00	5.64	15.83	2.63	6.40	69.49
6653	16.742	77.99	5.64	0.01	5.62	15.28	2.63	4.95	71.50
6665	16.765	78.62	5.44	0.01	5.59	15.79	3.71	6.03	68.86
6677	16.786	78.57	5.46	0.01	5.48	15.37	3.77	5.98	69.38
6689	16.807	77.81	5.71	0.01	5.80	16.39	3.77	5.64	68.40
6701	16.831	78.89	5.39	0.01	6.02	16.68	2.91	6.38	68.00
6712	16.850	80.13	4.99	0.00	5.85	16.88	3.36	6.97	66.94
6724	16.867	81.00	4.70	0.00	5.73	16.72	2.82	7.04	67.69
6736	16.887	78.75	5.41	0.00	5.99	17.39	1.68	6.20	68.74
6748	16.909	78.61	5.45	0.00	5.69	16.77	1.94	6.46	69.15

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
6760	16.931	78.39	5.52	0.00	5.34	16.70	2.12	6.69	69.14
6772	16.952	78.77	5.40	0.00	5.60	17.49	1.88	7.27	67.76
6784	16.974	79.04	5.31	0.00	5.85	17.07	1.20	7.88	67.99
6795	16.993	79.60	5.13	0.00	5.60	16.56	2.75	8.29	66.80
6807	17.012	79.43	5.19	0.00	5.63	15.70	4.27	7.59	66.81
6819	17.033	78.45	5.50	0.00	6.14	17.18	4.24	7.30	65.14
6831	17.056	79.08	5.31	0.00	5.93	16.46	4.03	6.85	66.73
6843	17.076	80.33	4.91	0.00	5.89	17.31	5.04	6.35	65.40
6855	17.094	80.89	4.73	0.00	5.98	18.43	3.72	6.31	65.57
6867	17.113	79.94	5.02	0.00	6.34	20.35	2.71	6.64	63.96
6879	17.133	80.19	4.95	0.00	5.91	19.73	2.33	7.42	64.61
6891	17.153	80.12	4.97	0.00	5.90	20.66	2.33	7.46	63.65
6903	17.172	80.13	4.96	0.00	5.77	20.33	1.74	7.71	64.46
6915	17.192	79.08	5.29	0.13	5.79	18.86	1.51	8.35	65.35
6927	17.214	78.75	5.40	0.13	5.52	18.68	0.78	9.33	65.57
6939	17.235	79.19	5.26	0.13	5.56	17.69	0.78	8.59	67.24
6951	17.255	79.64	5.12	0.13	5.63	17.34	0.78	8.54	67.58
6963	17.275	80.21	4.93	0.37	5.84	17.11	1.20	8.08	67.40
6975	17.294	80.67	4.79	0.25	5.87	17.62	1.66	7.68	66.92
6987	17.313	80.51	4.84	0.25	5.82	16.91	1.61	6.66	68.76
6999	17.332	80.14	4.96	0.25	5.81	17.41	2.29	6.32	67.92
7011	17.352	79.68	5.10	0.25	5.78	16.32	2.29	6.46	68.91
7023	17.372	79.59	5.13	0.00	5.74	15.51	1.14	6.88	70.73
7035	17.392	80.85	4.75	0.00	5.92	16.24	0.88	7.15	69.80
7047	17.411	81.48	4.56	0.00	6.03	16.12	1.39	8.11	68.36
7059	17.427	81.94	4.41	0.00	6.12	16.61	0.72	7.85	68.69
7071	17.446	81.26	4.61	0.00	6.33	16.83	1.06	8.32	67.46
7083	17.464	81.03	4.68	0.00	6.09	17.36	1.62	8.35	66.57
7095	17.482	80.11	4.98	0.00	5.91	16.76	1.42	7.99	67.91
7107	17.503	79.49	5.17	0.10	6.01	17.94	0.91	7.67	67.36
7119	17.524	79.79	5.08	0.10	5.86	17.14	0.90	8.60	67.39
7131	17.543	80.17	4.96	0.10	5.68	17.99	0.56	7.92	67.75
7143	17.562	80.19	4.95	0.10	5.80	19.01	0.00	6.54	68.54
7155	17.583	79.39	5.19	0.22	5.81	17.74	0.00	7.54	68.69
7167	17.603	80.30	4.91	0.12	5.64	16.68	0.00	7.16	70.40
7179	17.622	80.51	4.84	0.14	5.87	17.08	0.36	7.62	68.94
7192	17.642	81.25	4.62	0.14	5.83	17.32	0.36	8.68	67.68

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
7204	17.661	81.41	4.57	0.14	5.84	17.41	0.58	10.43	65.61
7216	17.678	81.30	4.60	0.02	5.81	18.91	0.58	9.81	64.87
7228	17.696	80.56	4.83	0.02	5.76	19.35	1.27	9.52	64.08
7240	17.716	79.72	5.09	0.00	5.71	19.24	1.01	10.21	63.83
7252	17.737	80.25	4.92	0.00	5.75	18.50	1.01	9.97	64.78
7265	17.757	80.41	4.87	0.00	5.69	17.70	0.78	9.09	66.75
7277	17.776	80.24	4.93	0.00	5.63	17.55	2.43	8.38	66.01
7289	17.796	79.30	5.22	0.00	5.63	17.29	1.74	8.36	66.99
7301	17.817	79.16	5.27	0.00	5.49	17.92	1.65	7.19	67.75
7313	17.838	80.11	4.97	0.00	5.33	18.07	1.65	5.88	69.07
7326	17.858	80.12	4.97	0.07	5.49	18.82	1.65	6.76	67.22
7338	17.878	80.68	4.80	0.07	5.56	18.86	0.45	7.67	67.40
7350	17.897	79.76	5.08	0.07	5.58	19.39	0.45	9.02	65.49
7362	17.917	80.30	4.91	0.07	5.56	19.18	0.54	8.60	66.05
7374	17.937	79.66	5.11	0.53	5.85	19.23	0.54	10.47	63.38
7387	17.958	80.64	4.81	0.46	5.73	19.23	0.54	10.49	63.55
7399	17.977	80.41	4.88	0.46	5.75	18.50	0.09	10.32	64.88
7411	17.996	80.76	4.77	0.46	5.80	18.24	0.29	10.78	64.43
7423	18.015	80.71	4.78	0.46	5.87	17.92	0.21	10.81	64.73
7436	18.035	81.37	4.58	0.00	5.85	17.25	1.27	9.87	65.76
7448	18.053	81.78	4.46	0.00	5.85	16.78	2.32	9.21	65.84
7460	18.070	81.12	4.66	0.00	5.88	17.47	2.58	8.84	65.23
7472	18.089	81.10	4.66	0.00	5.96	17.31	2.38	7.98	66.37
7485	18.110	81.18	4.64	0.00	5.96	16.53	2.38	8.26	66.88
7497	18.127	81.41	4.57	0.00	5.74	16.90	2.10	8.23	67.03
7509	18.145	80.56	4.83	0.00	5.48	16.08	1.07	8.21	69.16
7522	18.167	79.41	5.19	0.04	5.63	16.26	1.03	7.20	69.83
7534	18.188	80.03	5.00	0.04	5.36	16.17	1.03	7.13	70.27
7546	18.207	80.22	4.94	0.04	5.36	18.12	1.92	7.24	67.32
7559	18.227	80.84	4.75	0.04	5.40	17.31	1.13	6.69	69.42
7571	18.247	80.54	4.83	0.04	5.83	18.84	1.11	6.01	68.17
7583	18.265	81.72	4.48	0.00	5.70	18.19	1.82	6.84	67.45
7596	18.284	81.89	4.42	0.00	6.19	18.11	2.62	6.45	66.62
7608	18.301	82.71	4.19	0.00	6.14	16.27	2.31	5.46	69.81
7620	18.318	81.59	4.52	0.00	6.17	16.14	2.43	5.93	69.33
7633	18.337	81.74	4.48	0.00	6.09	14.66	3.36	5.98	69.91
7645	18.356	80.54	4.83	0.00	5.97	14.63	3.16	6.30	69.93

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
7657	18.374	80.56	4.83	0.00	5.95	15.64	2.97	6.39	69.06
7670	18.396	81.15	4.65	0.00	5.94	17.35	2.40	6.11	68.20
7682	18.413	81.69	4.49	0.00	6.15	18.20	2.56	6.07	67.02
7694	18.430	82.57	4.22	0.00	5.91	18.46	3.21	5.79	66.63
7707	18.449	81.54	4.53	0.00	6.02	17.81	4.28	4.63	67.27
7719	18.467	81.17	4.64	0.00	5.79	16.63	4.19	4.34	69.05
7732	18.487	80.81	4.75	0.00	5.75	15.09	4.19	5.45	69.53
7744	18.506	81.06	4.67	0.00	5.55	15.27	4.94	5.43	68.81
7756	18.524	80.85	4.74	0.00	5.91	15.84	3.90	6.53	67.82
7769	18.545	81.26	4.62	0.00	6.19	18.02	2.10	6.90	66.79
7781	18.563	82.45	4.27	0.00	6.09	18.09	1.84	7.36	66.63
7794	18.579	82.87	4.14	0.00	6.39	19.20	1.84	6.87	65.70
7806	18.596	83.31	4.01	0.00	6.34	20.43	1.32	7.28	64.63
7819	18.614	81.67	4.50	0.00	6.10	19.95	0.86	6.17	66.92
7831	18.631	81.43	4.57	0.00	5.65	18.72	3.45	6.51	65.66
7843	18.651	79.67	5.11	0.00	5.72	20.06	3.78	6.27	64.18
7856	18.673	80.58	4.83	0.00	5.35	19.32	5.57	6.43	63.33
7868	18.692	79.97	5.02	0.00	5.52	18.40	5.06	7.00	64.02
7881	18.712	81.20	4.64	0.00	5.49	19.04	4.97	8.60	61.90
7893	18.731	81.09	4.67	0.00	5.64	19.31	2.39	9.09	63.57
7906	18.750	81.88	4.43	0.00	5.55	18.18	2.46	8.89	64.91
7918	18.768	81.57	4.52	0.00	5.93	19.29	0.67	8.98	65.14
7931	18.787	82.17	4.35	0.00	5.90	18.78	0.67	6.71	67.95
7943	18.804	82.21	4.33	0.00	5.88	18.93	0.67	5.81	68.71
7956	18.822	82.25	4.32	0.00	5.85	18.69	0.67	6.09	68.70
7968	18.840	81.39	4.57	0.00	5.78	18.53	0.00	5.78	69.90
7981	18.859	80.90	4.73	0.00	5.76	18.05	0.00	5.88	70.31
7993	18.878	81.56	4.53	0.00	5.63	18.10	0.57	7.48	68.22
8006	18.898	81.16	4.65	0.01	5.63	17.31	1.02	7.28	68.75
8018	18.915	81.36	4.59	0.01	5.83	18.60	1.02	6.87	67.67
8031	18.936	81.33	4.60	0.01	6.13	18.62	1.12	6.02	68.09
8043	18.954	82.54	4.24	0.01	5.83	18.17	1.12	6.76	68.11
8056	18.970	82.34	4.30	0.01	5.91	18.57	1.97	7.05	66.48
8068	18.988	81.01	4.70	0.00	6.00	18.68	1.52	7.11	66.69
8081	19.010	80.37	4.89	0.00	6.18	17.57	1.52	7.15	67.58
8093	19.029	82.04	4.40	0.11	6.21	17.11	2.81	9.53	64.23
8106	19.046	83.42	3.98	0.11	6.35	16.80	2.81	9.05	64.87

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
8119	19.062	83.51	3.95	0.11	6.62	16.83	3.03	8.27	65.14
8131	19.078	83.22	4.04	0.11	6.68	15.51	3.54	9.14	65.03
8144	19.096	82.61	4.21	0.11	6.51	16.00	4.91	9.15	63.32
8156	19.112	83.15	4.06	0.00	6.13	15.68	4.52	7.47	66.20
8169	19.130	82.21	4.33	0.00	6.03	16.38	4.77	7.57	65.25
8182	19.148	81.92	4.42	0.00	5.80	15.85	3.13	6.89	68.32
8194	19.167	81.41	4.57	0.00	5.79	18.76	2.98	5.74	66.73
8207	19.186	81.74	4.47	0.00	5.43	18.08	3.07	5.66	67.76
8219	19.203	80.90	4.73	0.00	5.92	18.97	2.93	6.83	65.35
8232	19.224	81.73	4.49	0.03	5.92	17.35	4.17	6.92	65.62
8245	19.244	80.96	4.73	0.03	5.88	16.62	6.49	7.75	63.22
8257	19.261	81.94	4.42	0.03	5.76	16.04	6.68	7.90	63.59
8270	19.281	80.56	4.83	0.03	6.09	16.72	5.22	8.49	63.44
8282	19.300	81.49	4.55	0.03	5.77	15.78	5.97	7.94	64.51
8295	19.319	81.52	4.54	0.00	5.72	16.37	5.81	7.28	64.83
8308	19.338	82.02	4.38	0.00	5.78	16.86	4.42	7.63	65.30
8320	19.356	81.85	4.43	0.00	5.88	15.76	5.68	7.12	65.56
8333	19.374	81.95	4.40	0.00	5.74	15.76	6.72	6.13	65.64
8346	19.393	82.28	4.31	0.00	5.75	16.60	6.66	6.88	64.12
8358	19.410	82.03	4.38	0.00	5.97	17.06	5.32	7.36	64.29
8371	19.429	82.67	4.20	0.00	5.88	17.73	4.39	8.42	63.58
8538	19.661	82.24	4.32	0.00	5.90	18.45	2.59	9.48	63.58
8550	19.677	82.81	4.15	0.00	5.86	18.70	1.56	10.65	63.23
8561	19.693	82.14	4.35	0.00	5.65	19.51	0.01	10.49	64.33
8572	19.708	81.45	4.56	0.00	5.54	19.83	0.01	10.93	63.69
8584	19.727	81.24	4.62	0.00	5.64	19.59	0.04	9.89	64.85
8595	19.744	81.83	4.45	0.00	5.54	18.71	0.04	9.61	66.11
8606	19.759	83.10	4.07	0.00	5.57	16.80	0.03	9.46	68.14
8617	19.773	83.09	4.07	0.00	5.81	15.94	0.03	8.93	69.30
8629	19.790	83.39	3.99	0.00	5.95	15.44	0.40	8.31	69.90
8640	19.804	83.70	3.90	0.00	5.96	16.31	1.37	8.61	67.74
8651	19.818	83.97	3.82	0.00	6.01	16.29	1.37	8.06	68.26
8663	19.833	83.37	3.99	0.00	6.04	17.83	2.00	7.49	66.64
8674	19.848	83.07	4.08	0.00	6.06	17.54	2.27	6.52	67.61
8685	19.863	83.61	3.93	0.00	5.95	18.17	1.89	5.71	68.28
8697	19.878	84.19	3.76	0.00	5.81	17.02	1.31	5.40	70.46
8708	19.891	84.34	3.71	0.00	5.89	16.76	1.86	6.54	68.95

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
8719	19.904	83.82	3.86	0.00	6.07	16.80	1.57	7.61	67.95
8731	19.920	84.12	3.78	0.09	6.31	16.97	1.31	8.71	66.61
8742	19.933	84.83	3.58	0.09	6.38	16.15	1.31	9.46	66.62
8753	19.946	84.82	3.58	0.09	6.40	17.58	0.89	9.84	65.20
8765	19.960	83.66	3.92	0.09	6.29	18.49	1.90	8.59	64.64
8776	19.975	82.40	4.27	0.38	6.02	18.01	2.67	7.41	65.52
8787	19.991	82.06	4.37	0.29	5.60	21.23	2.67	6.72	63.48
8799	20.008	82.59	4.22	0.33	5.63	21.77	2.67	5.68	63.93
8810	20.023	83.09	4.07	0.33	5.60	20.10	4.21	4.56	65.21
8821	20.038	82.89	4.13	0.33	5.78	20.73	3.82	5.07	64.28
8833	20.054	83.04	4.09	0.03	5.06	18.38	16.72	3.92	55.89
8844	20.069	75.68	6.95	0.03	5.17	15.68	16.94	5.31	56.87
8855	20.099	76.14	6.81	0.00	4.98	15.47	16.94	7.48	55.14
8867	20.132	75.35	7.05	0.00	5.16	16.21	16.45	8.72	53.46
8878	20.147	82.68	4.19	0.00	5.11	16.25	15.29	9.26	54.09
8889	20.163	82.82	4.15	1.69	5.69	17.65	2.22	10.29	62.46
8901	20.178	82.40	4.28	1.69	5.50	16.82	2.33	10.10	63.56
8912	20.194	82.13	4.36	1.69	5.53	17.46	2.33	8.69	64.29
8924	20.212	81.84	4.44	1.69	5.32	17.74	1.80	9.08	64.37
8935	20.227	83.14	4.06	1.75	5.14	17.23	1.80	8.87	65.21
8946	20.242	83.76	3.88	0.06	5.24	19.90	0.85	9.50	64.45
8958	20.256	83.67	3.91	0.06	5.40	19.89	1.59	9.24	63.83
8969	20.271	83.28	4.02	0.06	5.41	19.73	1.59	10.52	62.69
8981	20.287	82.80	4.15	0.06	5.53	19.43	1.07	9.61	64.30
8992	20.302	83.16	4.05	0.00	5.75	19.14	1.52	10.31	63.27
9004	20.318	83.67	3.90	0.00	5.84	18.02	1.52	10.62	64.00
9015	20.332	83.43	3.97	0.00	5.88	18.14	0.45	10.08	65.45
9026	20.346	83.24	4.03	0.00	5.87	17.99	0.45	9.21	66.48
9038	20.363	83.49	3.96	0.00	5.78	17.27	1.06	9.29	66.59
9049	20.377	83.94	3.83	0.00	5.89	17.63	0.61	8.71	67.16
9061	20.391	84.83	3.58	0.00	6.24	18.54	1.61	7.31	66.30
9072	20.404	85.30	3.45	0.21	6.39	19.51	2.41	7.35	64.12
9084	20.417	85.87	3.29	0.21	6.52	20.57	2.41	8.38	61.91
9095	20.429	85.29	3.45	0.21	6.61	21.57	1.80	9.40	60.42
9107	20.443	84.76	3.60	0.21	6.44	21.19	1.80	10.27	60.09
9118	20.456	84.62	3.64	0.21	6.09	19.48	0.80	11.04	62.38
9130	20.470	84.34	3.72	0.00	5.99	18.81	0.22	11.59	63.39

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
9141	20.484	84.11	3.78	0.00	5.95	17.49	0.22	10.28	66.05
9153	20.500	83.77	3.88	0.00	5.91	16.23	0.22	10.35	67.29
9164	20.513	83.96	3.82	0.00	5.87	16.21	0.22	9.16	68.55
9176	20.528	83.86	3.85	0.00	5.84	17.28	1.00	10.33	65.56
9187	20.542	83.62	3.92	0.06	5.60	17.62	1.76	10.64	64.32
9199	20.558	83.50	3.95	0.19	5.62	18.02	1.76	12.20	62.22
9210	20.572	83.41	3.98	0.19	5.83	19.16	1.76	11.21	61.85
9222	20.588	84.18	3.76	0.19	5.81	19.49	1.76	11.36	61.40
9233	20.601	84.32	3.72	0.19	6.03	18.74	0.98	10.45	63.62
9245	20.616	84.92	3.55	0.13	6.58	19.72	0.00	10.87	62.71
9256	20.629	85.64	3.36	0.00	6.67	19.61	0.50	9.79	63.43
9268	20.641	86.19	3.21	0.00	6.53	19.13	0.55	9.62	64.18
9280	20.653	85.95	3.27	0.00	6.73	19.20	0.92	9.61	63.54
9291	20.666	85.17	3.48	0.35	6.53	19.67	0.92	9.17	63.35
9303	20.680	84.58	3.65	0.39	5.97	18.34	0.92	8.58	65.80
9314	20.693	83.42	3.98	0.39	5.84	18.27	1.45	7.74	66.31
9326	20.710	83.10	4.07	0.39	5.84	18.39	1.40	7.73	66.25
9337	20.725	83.42	3.98	0.39	5.67	17.95	2.06	7.50	66.43
9349	20.739	84.43	3.69	0.09	5.97	18.27	2.59	7.69	65.39
9361	20.754	84.75	3.60	0.05	6.22	18.43	2.66	8.24	64.39
9372	20.767	84.73	3.61	0.05	6.33	18.91	2.09	9.14	63.48
9384	20.781	85.01	3.53	0.05	6.18	18.29	2.09	9.95	63.44
9395	20.794	84.06	3.80	0.05	6.12	18.43	2.19	11.62	61.59
9407	20.809	83.71	3.90	0.00	5.71	18.16	2.78	11.94	61.41
9419	20.825	82.83	4.15	0.00	5.73	18.22	2.71	12.05	61.29
9430	20.840	83.60	3.93	0.00	5.77	17.73	2.25	12.35	61.90
9442	20.855	84.44	3.69	0.00	5.88	18.16	2.98	10.98	62.01
9454	20.869	85.05	3.52	0.00	5.89	17.82	1.84	10.04	64.40
9465	20.882	84.63	3.64	0.00	6.04	16.46	0.72	9.61	67.16
9477	20.897	83.96	3.82	0.00	5.95	15.98	1.79	9.72	66.56
9489	20.912	83.83	3.86	0.00	5.84	16.85	1.79	9.22	66.30
9500	20.926	84.24	3.74	0.00	6.00	17.20	1.28	10.99	64.53
9512	20.940	84.78	3.59	0.00	6.20	18.39	1.28	10.05	64.08
9524	20.954	85.30	3.45	0.00	6.15	18.46	1.28	10.47	63.64
9535	20.966	84.75	3.60	0.00	6.14	19.03	0.22	9.58	65.03
9547	20.981	84.30	3.73	0.00	6.19	18.14	0.22	9.59	65.87
9559	20.996	84.09	3.79	0.00	6.02	17.94	0.52	8.15	67.37

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
9571	21.011	84.43	3.69	0.01	5.67	17.60	0.52	9.41	66.79
9582	21.024	84.21	3.75	0.01	5.74	18.24	1.32	9.28	65.41
9594	21.039	83.84	3.85	0.38	5.99	17.77	2.95	8.93	63.98
9606	21.055	84.27	3.73	0.38	5.82	17.61	2.95	9.42	63.81
9618	21.069	84.80	3.59	0.38	5.75	17.33	3.16	9.45	63.92
9629	21.081	84.75	3.60	0.38	6.55	17.77	3.16	8.96	63.18
9641	21.096	85.98	3.28	0.38	6.40	19.65	2.76	9.60	61.20
9653	21.108	85.16	3.51	0.19	6.38	19.60	1.13	9.24	63.46
9665	21.122	85.99	3.28	0.19	6.56	20.03	1.13	9.82	62.28
9676	21.135	84.66	3.63	0.19	6.69	20.84	0.98	10.38	60.92
9688	21.148	85.69	3.34	0.19	6.10	21.17	0.98	11.71	59.85
9700	21.162	85.22	3.47	0.19	6.15	18.48	1.84	11.05	62.29
9712	21.175	84.88	3.56	0.00	5.92	19.05	1.84	12.04	61.15
9723	21.188	84.36	3.71	0.00	5.79	18.63	2.06	10.97	62.55
9735	21.203	84.17	3.76	0.01	5.67	17.23	2.65	12.57	61.87
9747	21.218	84.53	3.66	0.01	5.74	16.80	2.65	11.00	63.81
9759	21.232	85.53	3.39	0.01	5.67	17.46	2.39	11.65	62.82
9771	21.245	85.32	3.45	0.01	5.98	17.95	2.39	11.66	62.01
9782	21.258	85.81	3.31	0.01	6.21	18.49	2.17	12.23	60.90
9794	21.271	85.42	3.42	0.00	6.30	18.52	1.84	10.12	63.22
9806	21.284	86.00	3.26	0.00	6.48	17.45	1.84	10.34	63.89
9818	21.297	86.14	3.22	0.00	6.59	17.28	0.84	10.39	64.90
9830	21.310	86.09	3.23	0.44	6.45	17.33	0.84	10.46	64.48
9841	21.321	86.80	3.04	0.48	6.38	17.68	0.84	9.82	64.80
9853	21.333	87.02	2.99	0.48	6.28	18.25	0.07	10.49	64.43
9865	21.344	86.56	3.11	0.48	6.01	18.14	0.07	11.44	63.86
9877	21.357	86.08	3.24	0.48	6.12	18.18	0.76	10.87	63.59
9889	21.371	85.52	3.39	0.04	6.02	18.07	0.76	9.92	65.20
9901	21.383	85.86	3.29	0.00	6.02	16.92	2.30	10.41	64.35
9912	21.396	85.79	3.31	0.17	6.19	17.53	2.23	10.40	63.48
9924	21.409	85.59	3.37	0.17	6.14	17.19	2.23	9.66	64.61
9936	21.422	85.73	3.33	0.17	6.21	17.92	1.54	9.19	64.98
9948	21.435	85.80	3.31	0.17	6.27	16.45	1.76	10.17	65.18
9960	21.448	85.78	3.32	0.17	6.27	17.49	1.72	7.96	66.38
9972	21.461	85.19	3.48	0.00	6.39	16.63	1.72	8.40	66.86
9984	21.475	85.37	3.43	0.00	6.77	15.63	3.36	7.68	66.56
9996	21.489	86.18	3.22	0.08	6.74	15.41	3.36	9.25	65.16

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
10008	21.500	87.01	2.99	0.08	6.91	15.49	4.65	7.87	65.01
10020	21.512	87.29	2.91	0.08	6.57	17.29	4.17	9.05	62.84
10031	21.523	85.39	3.44	0.08	6.52	17.93	4.52	8.56	62.40
10043	21.537	85.45	3.42	0.16	6.11	19.72	5.44	10.63	57.94
10055	21.552	84.68	3.63	0.09	5.79	20.43	6.54	9.39	57.76
10067	21.565	84.88	3.57	0.09	5.50	20.66	7.20	9.55	57.00
10079	21.580	84.20	3.76	0.09	5.77	18.15	7.46	9.89	58.65
10091	21.595	84.84	3.58	0.09	5.61	17.70	7.11	9.79	59.70
10103	21.608	85.63	3.36	0.00	5.62	17.77	6.02	8.53	62.06
10115	21.621	85.52	3.39	0.00	5.92	16.18	4.93	8.59	64.38
10127	21.635	85.12	3.50	0.00	6.04	17.82	2.76	9.67	63.71
10139	21.649	85.89	3.29	0.03	6.06	17.88	2.73	8.93	64.36
10151	21.661	86.22	3.20	0.03	6.13	17.54	3.38	9.41	63.51
10163	21.673	86.68	3.08	0.09	6.19	16.46	3.95	8.44	64.86
10175	21.686	85.94	3.27	0.09	6.06	15.93	5.06	9.30	63.55
10187	21.699	85.51	3.40	0.09	5.96	14.49	5.37	9.04	65.05
10199	21.713	84.67	3.62	0.06	5.80	14.02	5.65	9.91	64.56
10211	21.727	84.16	3.76	0.06	5.86	14.05	5.04	9.30	65.69
10223	21.742	85.34	3.45	0.00	5.86	16.23	3.41	9.84	64.66
10235	21.756	85.36	3.44	0.52	6.03	17.44	3.30	9.73	62.99
10247	21.768	86.20	3.21	0.52	6.51	17.25	4.16	8.31	63.26
10259	21.782	86.46	3.14	0.52	6.50	18.08	3.11	7.93	63.86
10271	21.793	86.60	3.10	0.52	6.36	19.81	3.85	8.41	61.05
10283	21.805	86.37	3.16	0.52	6.36	18.38	3.76	8.80	62.19
10295	21.819	85.24	3.46	0.00	6.50	17.68	3.17	8.94	63.71
10307	21.832	85.93	3.28	0.00	6.26	18.81	2.00	9.86	63.06
10319	21.845	86.46	3.13	0.00	6.35	17.83	2.32	10.04	63.47
10332	21.858	86.99	2.99	0.00	6.48	17.07	1.55	9.29	65.62
10344	21.870	86.78	3.05	0.00	6.54	18.44	2.17	7.96	64.89
10356	21.882	86.47	3.13	0.00	6.37	19.11	1.75	7.08	65.69
10368	21.894	86.22	3.20	0.22	6.17	18.00	3.64	7.53	64.43
10380	21.907	86.09	3.23	0.22	6.41	17.42	3.75	8.22	63.97
10392	21.920	86.67	3.08	0.24	6.25	16.11	5.46	9.08	62.85
10404	21.931	86.32	3.17	0.28	6.23	14.34	4.51	10.56	64.07
10416	21.944	86.54	3.12	0.28	6.23	14.33	4.51	11.28	63.37
10428	21.957	85.94	3.28	0.06	6.24	16.91	3.71	10.67	62.42
10441	21.970	86.58	3.10	0.06	5.99	19.03	2.87	11.69	60.37

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
10453	21.983	86.46	3.13	0.04	6.19	20.08	1.16	11.42	61.11
10465	21.995	86.78	3.05	0.12	6.16	21.23	1.16	11.24	60.09
10477	22.007	86.36	3.16	0.12	6.03	21.16	1.53	11.30	59.86
10489	22.019	85.66	3.35	0.12	5.97	19.06	1.62	11.34	61.89
10501	22.033	85.30	3.45	0.19	6.16	18.02	1.54	11.25	62.83
10513	22.047	85.88	3.29	0.32	6.21	18.43	1.54	10.91	62.59
10526	22.060	86.95	3.00	0.27	6.18	17.92	1.54	11.48	62.61
10538	22.072	87.46	2.87	0.27	6.45	18.98	1.40	9.92	62.98
10550	22.083	87.67	2.81	0.27	6.36	18.97	1.15	10.71	62.53
10562	22.094	86.54	3.12	0.20	6.20	18.36	1.15	10.60	63.50
10574	22.107	86.18	3.22	0.07	6.46	19.04	1.71	11.58	61.14
10586	22.120	86.70	3.08	0.00	6.53	19.28	1.71	10.85	61.63
10599	22.132	87.45	2.88	0.00	6.50	18.45	1.48	12.55	61.00
10611	22.143	87.75	2.80	0.29	6.57	18.00	0.65	13.64	60.85
10623	22.155	86.91	3.01	0.29	6.55	18.92	1.23	13.15	59.86
10635	22.166	86.72	3.06	0.29	6.08	17.58	1.83	11.20	63.01
10647	22.179	86.64	3.09	0.29	5.91	16.99	1.83	11.77	63.21
10660	22.192	85.59	3.37	0.29	5.83	16.69	3.49	12.66	61.05
10672	22.206	85.87	3.30	0.00	5.81	16.97	3.40	9.91	63.91
10684	22.219	86.03	3.25	0.00	5.84	17.35	3.56	9.33	63.93
10696	22.231	86.73	3.06	0.00	6.06	17.43	2.38	11.25	62.87
10709	22.244	86.96	3.00	0.00	6.25	17.86	2.38	10.48	63.02
10721	22.256	86.50	3.12	0.00	6.36	18.87	1.34	9.25	64.18
10733	22.268	86.95	3.00	0.00	6.63	19.38	1.85	10.26	61.88
10745	22.280	87.14	2.95	0.18	6.83	19.86	1.11	10.74	61.27
10758	22.292	87.63	2.82	0.18	6.80	19.63	2.21	10.53	60.65
10770	22.303	87.83	2.77	0.20	7.11	19.54	2.21	10.98	59.96
10782	22.314	88.09	2.70	0.20	6.77	18.49	1.82	11.25	61.48
10794	22.325	86.91	3.02	0.20	6.66	18.19	1.31	13.47	60.17
10807	22.338	86.57	3.11	0.13	6.57	17.82	1.31	14.02	60.16
10819	22.352	86.47	3.14	0.13	6.48	18.88	0.21	15.40	58.89
10831	22.363	87.48	2.86	0.11	6.27	19.52	0.21	15.21	58.68
10844	22.375	87.79	2.78	0.20	6.70	20.87	2.20	14.26	55.76
10856	22.386	87.76	2.79	0.20	6.86	23.47	2.20	12.98	54.29
10868	22.397	88.17	2.68	0.09	6.95	23.12	2.25	13.90	53.70
10881	22.408	88.00	2.73	0.09	6.92	22.40	2.86	11.11	56.61
10893	22.419	87.56	2.84	0.09	6.69	22.40	3.22	11.69	55.92

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
10905	22.431	86.44	3.14	0.00	6.43	21.48	1.65	12.47	57.98
10918	22.445	85.97	3.27	0.00	6.89	19.98	2.05	11.11	59.96
10930	22.458	87.26	2.94	0.24	6.85	22.22	2.02	9.43	59.24
10942	22.468	88.20	2.69	0.24	7.07	21.21	3.22	9.32	58.93
10955	22.479	88.92	2.50	0.24	7.33	20.36	3.75	9.32	59.00
10967	22.489	87.46	2.87	0.24	7.72	20.60	3.31	10.23	57.91
10980	22.502	87.84	2.77	0.24	7.13	19.95	2.91	10.84	58.94
10992	22.513	87.93	2.75	0.18	7.04	16.57	4.95	11.85	59.41
11005	22.524	88.10	2.70	0.18	6.77	18.22	3.13	12.72	58.99
11017	22.535	87.75	2.79	0.18	6.62	18.20	3.62	12.59	58.79
11030	22.547	86.99	2.99	0.18	6.35	18.61	3.42	9.89	61.55
11042	22.559	87.49	2.86	0.20	6.20	17.94	3.78	11.05	60.83
11055	22.572	86.93	3.01	0.02	6.23	18.93	1.73	9.02	64.07
11067	22.583	87.33	2.90	0.26	6.15	18.15	2.09	9.17	64.19
11080	22.596	86.46	3.13	0.26	6.11	17.99	1.18	8.60	65.85
11092	22.608	86.37	3.16	0.29	5.40	15.27	1.70	19.15	58.19
11105	22.622	82.85	4.21	0.27	5.36	15.95	2.26	18.51	57.65
11117	22.641	82.90	4.19	0.27	5.32	16.29	2.26	18.90	56.96
11130	22.661	83.49	4.04	0.02	5.25	16.48	1.90	20.88	55.46
11142	22.673	86.38	3.16	0.19	5.26	18.22	1.44	21.15	53.74
11155	22.686	86.44	3.14	0.16	5.64	20.32	0.92	12.09	60.87
11167	22.699	85.40	3.42	0.16	5.68	18.80	0.00	11.90	63.46
11180	22.714	85.84	3.30	0.16	5.68	18.27	0.00	13.06	62.82
11192	22.727	86.10	3.23	0.25	6.04	18.63	0.25	11.08	63.74
11205	22.740	87.37	2.89	0.09	6.29	19.00	0.25	10.65	63.72
11217	22.751	87.75	2.79	0.09	6.65	19.64	1.00	9.39	63.23
11230	22.762	88.35	2.64	0.09	6.63	20.49	1.00	10.46	61.33
11242	22.773	88.21	2.67	0.28	6.72	19.90	1.45	9.42	62.23
11255	22.784	88.35	2.64	0.20	6.63	20.25	1.20	9.17	62.56
11267	22.795	88.17	2.68	0.20	6.57	18.26	1.20	9.96	63.81
11280	22.806	88.29	2.65	0.20	6.44	17.36	2.24	12.81	60.95
11293	22.817	87.90	2.75	0.20	6.46	17.10	2.24	11.18	62.82
11305	22.828	87.42	2.88	0.00	6.52	18.24	1.80	11.87	61.57
11318	22.841	87.94	2.75	0.00	6.32	16.80	1.80	13.21	61.87
11330	22.852	87.72	2.81	0.00	6.10	21.00	2.94	11.66	58.30
11343	22.863	87.46	2.88	0.00	6.16	21.85	2.11	9.93	59.95
11356	22.877	86.85	3.03	0.00	6.26	23.16	2.31	11.08	57.19

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
11368	22.888	87.24	2.93	0.00	6.37	22.08	2.38	11.48	57.69
11381	22.900	88.76	2.54	0.00	6.42	22.77	2.38	11.75	56.68
11394	22.911	88.72	2.55	0.00	6.37	18.91	1.67	13.55	59.51
11406	22.920	88.50	2.61	0.00	6.51	18.72	2.80	13.22	58.75
11419	22.933	87.22	2.93	0.06	6.56	17.72	4.02	11.48	60.16
11431	22.944	87.18	2.94	0.25	6.09	19.50	4.86	11.54	57.76
11444	22.957	86.60	3.10	0.26	6.24	18.62	4.86	10.92	59.10
11457	22.970	87.14	2.96	0.26	6.71	18.41	5.39	11.61	57.62
11469	22.982	87.57	2.85	0.26	6.72	18.64	3.89	12.32	58.18
11482	22.993	88.70	2.55	0.32	6.95	18.42	3.52	14.12	56.67
11495	23.004	89.11	2.45	0.13	6.99	17.01	5.03	15.13	55.71
11508	23.014	88.09	2.71	0.12	6.71	17.38	5.75	15.62	54.42
11674	23.166	87.04	2.99	0.12	6.39	17.92	5.64	14.73	55.20
11686	23.179	86.35	3.16	0.12	6.30	17.47	5.04	13.72	57.34
11698	23.192	86.85	3.03	0.00	6.00	19.59	6.04	14.31	54.06
11710	23.203	87.60	2.83	0.00	6.30	20.45	3.61	14.70	54.94
11721	23.213	88.12	2.70	0.00	6.50	20.81	2.89	13.62	56.17
11732	23.222	88.49	2.60	0.00	6.56	20.11	2.05	13.60	57.67
11743	23.231	89.08	2.45	0.00	6.54	20.54	3.24	14.27	55.42
11755	23.241	88.86	2.51	0.00	6.64	19.30	1.19	13.37	59.50
11766	23.250	88.89	2.50	0.00	6.71	19.03	1.19	11.73	61.34
11777	23.259	88.92	2.49	0.00	6.67	18.80	1.19	11.60	61.73
11788	23.268	88.61	2.57	0.14	6.99	18.98	1.19	12.60	60.10
11800	23.278	89.12	2.45	0.14	6.98	18.15	1.56	14.76	58.40
11811	23.287	88.50	2.60	0.14	6.96	18.19	2.64	16.21	55.84
11822	23.296	88.83	2.52	0.14	6.69	17.64	2.64	17.32	55.56
11833	23.306	88.02	2.72	0.23	6.96	19.20	3.31	17.98	52.31
11845	23.317	88.63	2.57	0.14	6.61	19.98	3.39	16.12	53.76
11856	23.326	88.93	2.49	0.14	6.57	20.34	3.57	14.43	54.95
11867	23.335	89.26	2.41	0.14	6.45	19.07	2.50	14.48	57.36
11879	23.344	88.66	2.56	0.16	6.79	19.06	3.28	12.68	58.03
11890	23.354	88.83	2.52	0.07	6.63	17.94	2.99	13.36	59.02
11901	23.363	88.76	2.54	0.08	6.65	18.99	2.91	13.08	58.30
11913	23.372	88.87	2.51	0.08	6.67	19.16	1.16	13.89	59.04
11924	23.382	88.80	2.52	0.08	6.58	19.42	1.16	12.43	60.33
11935	23.391	87.98	2.74	0.06	6.43	19.74	0.66	12.62	60.49
11947	23.402	88.22	2.68	0.06	6.55	21.06	0.29	14.47	57.58

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
11958	23.412	88.11	2.71	0.00	6.44	19.72	0.70	15.31	57.82
11969	23.421	88.98	2.48	0.49	6.35	19.89	0.70	12.83	59.74
11981	23.431	89.18	2.43	0.49	6.67	19.95	2.06	13.21	57.62
11992	23.440	89.22	2.42	0.58	6.35	20.85	3.12	13.40	55.71
12003	23.448	88.61	2.57	0.58	6.26	18.90	3.12	10.29	60.86
12015	23.459	88.47	2.61	0.58	6.40	19.04	2.70	11.51	59.77
12026	23.469	88.10	2.70	0.09	6.60	19.96	2.70	13.26	57.40
12037	23.478	88.88	2.50	0.09	6.30	19.85	2.41	13.56	57.80
12049	23.488	88.60	2.57	0.00	6.42	20.14	1.86	13.88	57.69
12060	23.497	88.35	2.64	0.00	6.46	21.73	2.43	15.72	53.66
12072	23.508	88.33	2.64	0.00	6.38	21.30	5.24	14.39	52.69
12083	23.517	88.21	2.67	0.00	6.75	20.87	5.24	16.59	50.57
12094	23.527	89.47	2.36	0.11	7.21	22.48	4.62	15.43	50.14
12106	23.536	90.04	2.22	0.50	7.71	22.27	4.24	14.92	50.36
12117	23.543	91.07	1.96	0.88	7.59	21.30	3.89	14.73	51.62
12129	23.551	90.09	2.20	0.88	7.60	21.96	2.32	14.27	52.98
12140	23.559	89.09	2.45	0.98	6.97	19.49	4.71	12.41	55.44
12152	23.570	87.87	2.76	0.87	6.65	17.87	5.35	13.40	55.86
12163	23.580	87.98	2.73	0.48	6.36	17.80	4.93	15.77	54.66
12174	23.590	88.38	2.63	0.10	6.28	16.87	7.34	15.08	54.33
12186	23.600	88.62	2.57	0.38	6.46	17.18	6.09	16.45	53.44
12197	23.609	89.39	2.38	0.28	6.67	18.66	5.07	15.78	53.54
12209	23.618	89.35	2.39	0.28	7.60	20.47	3.98	15.95	51.72
12220	23.626	91.13	1.95	0.28	7.78	19.77	3.98	15.13	53.06
12232	23.634	90.86	2.02	0.49	8.26	20.74	2.73	14.78	53.00
12243	23.640	91.67	1.82	0.21	8.62	16.83	2.73	14.89	56.72
12255	23.648	91.05	1.97	0.21	8.47	16.13	2.43	15.26	57.50
12266	23.655	90.20	2.18	0.21	7.78	14.26	4.22	13.81	59.73
12278	23.664	89.95	2.24	0.61	7.91	14.24	4.22	12.85	60.18
12289	23.673	90.32	2.15	0.40	7.58	14.19	4.16	12.36	61.32
12301	23.680	90.91	2.00	0.61	6.83	15.28	7.39	12.06	57.84
12312	23.688	89.50	2.36	0.80	7.08	14.75	9.04	11.93	56.40
12324	23.698	88.71	2.55	0.80	7.87	18.84	10.01	13.61	48.87
12335	23.708	90.04	2.24	0.40	7.42	17.80	10.30	13.64	50.43
12347	23.715	90.84	2.03	0.40	7.54	16.34	10.42	14.10	51.20
12358	23.722	90.63	2.08	0.28	7.74	18.78	9.46	14.41	49.33
12370	23.732	88.70	2.55	0.20	7.88	19.90	6.73	13.89	51.40

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
12382	23.742	89.35	2.39	0.20	6.80	16.84	3.97	13.61	58.57
12393	23.751	89.01	2.47	0.29	6.66	16.92	9.30	12.88	53.95
12405	23.760	88.74	2.54	0.31	6.34	19.66	8.86	11.93	52.90
12416	23.770	87.96	2.74	0.21	6.22	18.85	6.59	13.50	54.63
12428	23.781	87.92	2.75	0.11	5.84	19.82	7.37	13.88	52.98
12439	23.790	88.36	2.64	0.11	5.59	19.44	8.33	12.60	53.93
12451	23.801	88.01	2.72	0.42	5.95	20.32	4.32	12.67	56.33
12463	23.812	88.72	2.55	0.41	6.18	16.84	3.35	15.17	58.05
12474	23.821	89.20	2.42	0.41	6.34	16.23	4.31	13.14	59.57
12486	23.829	89.55	2.34	0.41	6.66	15.76	6.18	12.29	58.70
12497	23.838	89.51	2.34	0.41	6.81	15.49	7.14	14.12	56.04
12509	23.848	88.75	2.54	0.15	6.59	14.83	5.94	15.10	57.39
12521	23.858	89.09	2.45	2.09	6.60	16.94	6.29	13.33	54.76
12532	23.867	89.07	2.46	2.09	6.80	17.90	5.85	13.21	54.16
12544	23.876	89.90	2.25	2.25	6.66	17.86	3.20	14.80	55.24
12555	23.884	90.23	2.17	2.25	6.74	19.18	2.19	12.46	57.18
12567	23.892	89.73	2.29	2.10	6.84	20.19	2.01	13.08	55.78
12579	23.901	89.59	2.33	0.31	6.75	20.74	1.67	11.34	59.20
12590	23.910	89.32	2.39	0.31	6.84	21.93	1.79	10.28	58.85
12602	23.919	89.99	2.23	0.15	7.01	22.72	2.61	10.03	57.48
12614	23.928	90.32	2.14	0.15	6.91	22.37	3.76	11.29	55.52
12625	23.935	89.77	2.28	0.20	6.75	21.35	3.53	9.67	58.50
12637	23.945	89.29	2.40	0.05	7.00	20.63	3.87	13.57	54.87
12649	23.955	89.52	2.34	0.08	6.80	19.59	3.46	15.72	54.35
12660	23.963	90.01	2.22	0.22	6.67	19.09	3.42	15.62	54.98
12672	23.971	90.27	2.16	0.38	6.63	18.49	1.36	16.29	56.85
12684	23.980	89.67	2.31	0.36	6.69	21.32	1.36	16.40	53.87
12696	23.989	89.57	2.33	0.36	6.47	21.62	1.89	15.24	54.42
12707	23.998	89.16	2.43	0.33	6.51	22.38	2.05	13.91	54.82
12719	24.008	89.35	2.38	0.19	5.99	22.75	1.52	13.30	56.25
12731	24.017	88.49	2.61	0.03	6.34	22.96	2.31	12.68	55.68
12743	24.027	88.87	2.51	0.00	6.37	21.70	2.31	12.81	56.81
12754	24.037	88.84	2.52	0.00	6.41	21.57	1.82	11.63	58.56
12766	24.046	89.90	2.25	0.04	6.22	20.55	2.53	11.87	58.78
12778	24.055	89.28	2.40	0.04	6.74	18.75	3.07	11.65	59.75
12789	24.064	89.34	2.39	0.04	6.95	20.11	2.28	11.65	58.97
12801	24.073	89.84	2.27	0.04	7.41	19.68	3.84	12.61	56.43

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
12813	24.082	90.51	2.10	0.12	7.38	21.51	3.45	13.07	54.46
12825	24.090	90.33	2.14	0.07	7.79	22.96	2.34	13.34	53.49
12837	24.099	90.41	2.12	0.46	7.88	24.09	1.87	16.05	49.65
12848	24.106	90.51	2.10	0.46	7.45	22.95	2.29	16.74	50.11
12860	24.114	90.21	2.17	0.46	7.26	22.76	1.28	16.82	51.41
12872	24.123	89.94	2.24	0.57	7.22	21.06	1.96	16.01	53.18
12884	24.132	89.22	2.42	0.57	7.10	20.86	1.96	16.02	53.49
12896	24.141	90.34	2.15	0.18	7.26	21.71	2.49	12.76	55.60
12908	24.150	90.72	2.05	0.18	7.21	21.47	3.70	13.15	54.29
12919	24.156	90.77	2.04	0.18	7.38	19.46	4.33	12.81	55.83
12931	24.165	90.58	2.09	0.00	7.31	20.06	5.24	11.55	55.85
12943	24.174	89.66	2.31	0.02	7.34	19.35	5.24	10.81	57.24
12955	24.183	90.89	2.01	0.02	6.97	19.14	4.39	12.82	56.66
12967	24.191	90.81	2.03	0.03	7.32	19.52	2.76	10.47	59.89
12979	24.198	91.66	1.82	0.03	6.93	21.05	2.76	9.98	59.24
12991	24.205	91.10	1.95	0.03	6.96	20.73	1.78	12.18	58.31
13003	24.213	90.46	2.11	0.10	6.55	21.12	1.78	14.15	56.31
13015	24.222	89.25	2.41	0.10	6.73	21.20	2.46	13.22	56.29
13027	24.232	89.29	2.40	0.09	6.51	21.80	2.46	13.62	55.53
13039	24.241	89.99	2.23	0.09	6.83	23.06	3.78	12.85	53.38
13051	24.249	91.08	1.96	0.09	7.16	23.50	3.93	13.44	51.87
13063	24.257	91.25	1.92	0.01	7.48	23.75	3.93	10.00	54.84
13075	24.264	90.80	2.03	0.01	7.45	23.62	3.93	11.06	53.93
13087	24.273	90.63	2.07	0.33	7.48	23.56	3.93	12.63	52.08
13098	24.280	90.69	2.05	0.51	7.33	22.45	1.42	15.31	52.97
13110	24.288	90.94	1.99	0.51	7.17	22.28	0.68	15.63	53.72
13122	24.296	90.70	2.05	0.51	7.30	21.97	0.68	17.17	52.36
13134	24.304	91.09	1.96	1.17	7.58	23.44	0.00	16.46	51.35
13146	24.312	92.02	1.74	0.99	7.64	23.06	0.00	16.09	52.23
13158	24.318	92.32	1.67	0.79	7.61	23.38	0.00	15.10	53.12
13170	24.324	92.19	1.70	0.79	7.56	23.86	0.19	14.65	52.95
13182	24.332	91.54	1.85	0.79	7.53	24.62	0.19	15.10	51.77
13194	24.339	91.69	1.81	0.14	7.06	23.70	1.84	15.51	51.75
13206	24.346	91.17	1.94	0.00	6.97	23.22	1.84	14.73	53.24
13218	24.354	90.76	2.04	0.00	6.68	23.94	1.84	14.43	53.10
13230	24.362	90.02	2.22	0.00	6.72	23.09	3.03	12.85	54.31
13243	24.372	90.01	2.22	0.00	6.69	23.39	3.03	11.08	55.82

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
13255	24.381	90.15	2.19	0.00	6.95	22.50	1.37	10.20	58.98
13267	24.389	90.84	2.02	0.00	7.29	24.05	1.85	10.16	56.65
13279	24.397	91.38	1.89	0.00	7.45	22.73	2.32	11.89	55.61
13291	24.404	91.11	1.95	0.00	7.61	21.47	0.95	13.28	56.69
13303	24.412	91.21	1.93	0.05	7.26	18.95	0.95	16.62	56.17
13315	24.420	90.31	2.15	0.05	7.44	17.12	0.95	17.43	57.01
13327	24.428	91.14	1.95	0.20	7.44	18.65	0.47	21.82	51.42
13339	24.436	91.48	1.87	0.20	7.80	18.65	0.36	21.52	51.48
13351	24.443	92.16	1.70	0.20	7.85	19.90	0.36	21.29	50.41
13363	24.449	91.77	1.79	0.15	7.84	20.03	0.36	21.64	49.98
13375	24.457	90.91	2.00	0.45	7.87	23.96	0.36	22.11	45.26
13387	24.465	91.29	1.91	0.30	7.45	20.61	2.15	18.25	51.25
13400	24.473	90.80	2.03	0.38	7.08	22.16	3.07	17.86	49.46
13412	24.481	90.80	2.03	0.38	6.82	23.12	3.55	15.90	50.23
13424	24.490	90.55	2.09	0.38	7.19	24.34	4.07	15.16	48.86
13436	24.498	91.12	1.95	0.07	6.56	21.72	4.07	14.20	53.37
13448	24.505	91.09	1.96	0.32	7.07	21.32	4.12	12.76	54.42
13460	24.513	91.35	1.90	0.24	7.38	22.30	2.84	13.18	54.06
13472	24.520	91.53	1.85	0.24	7.95	21.37	2.35	17.26	50.83
13484	24.527	92.68	1.58	0.24	7.47	20.53	2.59	17.14	52.02
13497	24.534	91.62	1.84	0.39	7.81	21.92	2.59	15.42	51.87
13509	24.541	91.43	1.88	0.14	7.39	22.97	0.76	17.92	50.81
13521	24.549	90.43	2.12	0.17	7.16	22.60	1.30	17.32	51.45
13533	24.557	90.97	1.98	0.20	6.62	22.97	1.30	16.68	52.23
13545	24.565	91.14	1.94	0.70	7.29	24.90	1.56	15.80	49.75
13557	24.573	91.98	1.75	0.56	7.44	24.01	1.77	21.00	45.22
13570	24.580	92.24	1.68	0.71	7.10	22.30	3.87	21.79	44.24
13582	24.586	91.08	1.97	0.69	6.92	21.37	3.76	21.26	46.00
13594	24.595	90.60	2.08	0.66	7.29	21.49	3.76	19.80	47.00
13606	24.604	90.96	2.00	0.22	6.89	20.17	2.73	21.41	48.59
13618	24.610	91.46	1.87	0.22	6.68	18.83	3.95	18.07	52.25
13631	24.618	91.58	1.84	0.06	7.05	20.94	1.85	17.44	52.66
13643	24.626	90.88	2.01	0.19	7.32	18.83	3.68	17.74	52.24
13655	24.634	91.40	1.88	0.44	7.25	19.94	3.97	18.46	49.94
13667	24.641	91.60	1.84	0.38	7.56	23.31	4.30	16.31	48.14
13679	24.648	92.15	1.70	0.38	7.71	24.33	4.44	15.87	47.27
13692	24.655	92.38	1.65	0.38	7.58	23.14	6.02	16.16	46.72

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
13704	24.662	91.75	1.80	0.25	7.89	26.80	3.77	17.18	44.11
13716	24.669	92.22	1.69	0.00	7.83	26.50	3.56	16.60	45.52
13728	24.676	92.31	1.67	0.00	7.39	22.70	4.61	16.66	48.64
13741	24.682	92.02	1.74	0.31	7.37	22.37	5.01	17.71	47.24
13753	24.690	91.23	1.93	0.31	7.38	22.74	5.47	17.50	46.60
13765	24.698	90.35	2.14	0.31	7.14	20.28	5.81	17.38	49.08
13778	24.707	91.10	1.96	0.31	6.84	21.47	6.59	17.01	47.78
13790	24.715	90.88	2.01	0.45	7.28	22.60	5.21	18.91	45.56
13802	24.722	92.00	1.74	0.15	7.23	22.20	3.87	18.78	47.77
13815	24.730	91.98	1.75	0.15	7.46	23.05	2.49	16.91	49.93
13827	24.736	92.19	1.69	0.15	7.62	23.56	4.25	13.83	50.59
13839	24.743	92.14	1.71	0.15	7.63	22.50	3.40	15.59	50.74
13851	24.750	91.92	1.76	0.00	7.25	21.67	5.64	17.65	47.79
13864	24.757	91.45	1.87	0.00	7.26	24.09	5.01	17.63	46.02
13876	24.765	91.07	1.96	0.00	7.13	25.14	4.35	19.11	44.28
13888	24.773	91.25	1.92	0.00	6.62	25.67	2.24	21.64	43.82
13901	24.781	91.11	1.95	0.00	6.58	27.05	2.27	20.00	44.10
13913	24.789	91.14	1.95	0.52	6.45	27.05	1.42	17.71	46.85
13925	24.797	90.65	2.07	0.52	6.04	25.07	1.98	18.36	48.03
13938	24.805	90.71	2.05	0.52	6.43	24.74	3.21	17.56	47.54
13950	24.814	91.10	1.96	0.52	6.51	24.10	5.85	15.44	47.58
13963	24.822	91.41	1.88	0.92	6.79	19.37	6.94	18.75	47.23
13975	24.828	92.41	1.64	0.40	7.09	19.69	6.62	19.23	46.97
13987	24.835	92.31	1.67	0.78	7.44	20.51	8.20	18.76	44.30
14000	24.842	92.48	1.63	0.78	7.05	18.90	6.97	21.00	45.29
14012	24.848	91.94	1.75	0.78	7.43	19.83	4.58	21.91	45.46
14024	24.856	91.95	1.75	0.50	7.07	23.72	4.77	19.61	44.33
14037	24.863	91.72	1.81	0.50	7.91	23.23	3.70	20.34	44.33
14049	24.870	93.07	1.50	0.12	7.78	22.27	3.41	19.36	47.06
14062	24.876	92.70	1.58	0.12	8.22	25.04	3.41	19.51	43.70
14074	24.882	93.41	1.42	0.12	7.79	23.92	5.19	21.70	41.29
14086	24.888	92.24	1.68	0.09	8.22	22.17	5.16	22.64	41.72
14099	24.895	92.69	1.58	0.09	7.14	21.59	6.66	20.43	44.09
14111	24.902	91.92	1.76	0.41	7.47	22.86	4.82	22.90	41.54
14124	24.909	92.24	1.68	0.41	7.13	21.10	5.67	19.76	45.94
14136	24.916	91.80	1.79	0.56	7.04	22.39	3.64	18.31	48.06
14149	24.923	92.02	1.74	0.47	7.23	23.60	2.47	17.58	48.66

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
14161	24.931	92.60	1.60	0.47	7.54	22.67	0.97	18.54	49.81
14174	24.937	93.05	1.50	0.38	7.43	20.08	1.78	17.10	53.23
14186	24.942	93.68	1.35	0.38	7.54	20.28	1.47	19.45	50.88
14198	24.948	93.00	1.51	0.23	8.73	20.02	2.31	15.90	52.82
14211	24.954	94.07	1.27	0.23	8.35	19.27	3.80	13.12	55.24
14223	24.959	93.98	1.29	0.23	8.27	20.06	3.80	13.77	53.88
14236	24.964	94.09	1.26	0.03	8.75	24.34	5.56	16.15	45.17
14248	24.970	93.40	1.41	0.03	8.47	24.14	5.02	15.37	46.97
14261	24.976	92.98	1.51	0.03	8.19	23.81	6.93	16.33	44.71
14273	24.982	93.43	1.41	0.17	8.52	22.40	7.45	17.98	43.48
14286	24.988	93.13	1.48	0.28	8.42	24.47	9.34	16.30	41.20
14298	24.993	93.47	1.40	0.67	8.02	21.59	7.29	15.00	47.43
14311	25.000	93.33	1.43	0.93	8.16	21.68	9.22	14.18	45.82
14324	25.006	93.09	1.48	1.09	7.76	21.97	7.51	17.85	43.83
14336	25.012	93.23	1.45	0.96	7.71	22.66	5.39	20.14	43.14
14349	25.018	92.96	1.51	0.84	8.88	25.57	3.51	21.95	39.25
14361	25.024	93.71	1.34	0.99	9.67	28.13	2.99	21.18	37.05
14374	25.029	94.44	1.18	0.73	9.52	26.58	2.93	22.51	37.73
14386	25.033	94.26	1.22	0.57	9.62	26.27	4.04	21.17	38.34
14399	25.039	93.93	1.30	0.57	9.42	28.50	6.98	19.22	35.31
14411	25.045	93.21	1.46	0.57	8.38	27.80	6.98	16.02	40.25
14424	25.051	93.43	1.41	0.29	7.47	26.52	6.98	16.83	41.90
14437	25.057	93.13	1.47	0.41	7.25	29.19	7.61	16.16	39.39
14449	25.063	92.27	1.68	0.64	6.82	29.92	7.86	14.90	39.86
14462	25.070	91.95	1.75	1.14	6.59	27.80	6.93	14.56	42.98
14474	25.078	91.75	1.80	1.29	5.47	20.86	7.53	13.94	50.91
14487	25.085	85.80	3.60	0.99	6.02	20.20	8.79	12.74	51.25
14500	25.104	86.49	3.44	0.93	6.76	20.14	7.05	10.20	54.91
14512	25.121	87.02	3.32	1.09	7.00	20.23	8.64	10.23	52.81
14525	25.127	93.98	1.28	0.58	7.14	22.08	7.35	12.34	50.51
14537	25.132	93.49	1.39	0.44	8.75	28.54	6.74	15.76	39.78
14550	25.138	93.69	1.35	0.56	7.86	27.13	11.06	16.17	37.21
14563	25.144	93.25	1.45	0.51	7.68	24.04	13.29	17.73	36.76
14575	25.149	93.58	1.37	0.27	7.38	24.75	9.29	19.91	38.39
14588	25.156	93.13	1.48	0.27	7.42	24.77	11.98	18.57	37.00
14601	25.162	93.41	1.41	0.58	7.49	23.09	11.98	19.96	36.90
14613	25.167	93.88	1.31	0.69	7.84	25.71	7.46	20.86	37.44

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
14626	25.173	93.96	1.29	0.69	7.88	28.07	4.46	23.45	35.45
14639	25.178	94.23	1.22	0.54	8.43	28.27	4.46	24.00	34.31
14651	25.183	94.01	1.27	0.54	8.29	28.86	3.21	22.32	36.79
14763	25.228	93.86	1.31	0.52	7.55	26.89	4.53	19.94	40.58
14775	25.234	93.39	1.42	0.29	7.78	24.65	3.47	21.36	42.45
14787	25.240	93.40	1.41	0.29	7.46	25.16	3.47	22.11	41.50
14798	25.245	93.34	1.43	0.80	7.49	24.05	4.60	21.08	41.99
14809	25.249	94.06	1.26	0.80	7.58	23.01	2.45	22.24	43.93
14821	25.255	93.84	1.31	0.51	8.23	25.18	1.12	18.86	46.10
14832	25.259	94.46	1.17	1.92	8.82	30.79	1.12	12.62	44.73
14843	25.263	94.95	1.07	2.50	9.40	28.98	1.69	13.55	43.88
14854	25.267	95.13	1.02	2.57	9.48	28.47	1.20	15.15	43.12
14866	25.271	95.17	1.02	4.30	9.69	28.55	5.96	14.58	36.93
14877	25.275	94.55	1.15	4.48	9.55	28.42	5.96	20.17	31.42
14888	25.279	94.92	1.07	3.07	9.13	21.09	8.53	27.10	31.09
14899	25.283	95.18	1.01	2.48	8.67	23.15	9.17	25.08	31.45
14911	25.286	95.16	1.02	1.90	8.33	23.21	9.32	24.38	32.86
14922	25.290	94.81	1.09	0.51	8.91	20.60	8.65	26.96	34.38
14933	25.295	94.75	1.11	0.33	8.90	20.46	9.14	24.42	36.76
14945	25.299	94.69	1.12	0.33	8.56	23.00	8.51	20.32	39.28
14956	25.303	94.60	1.14	0.83	8.63	26.11	7.66	16.54	40.22
14967	25.307	94.46	1.17	1.08	8.58	24.64	9.58	16.71	39.41
14979	25.312	94.73	1.11	2.26	8.50	25.76	9.82	18.11	35.54
14990	25.315	95.40	0.97	2.26	8.03	25.97	10.50	20.42	32.82
15001	25.319	94.65	1.14	2.69	7.69	26.25	11.92	21.75	29.70
15013	25.323	93.93	1.30	2.18	7.99	21.76	12.96	27.31	27.80
15024	25.329	93.59	1.37	1.93	7.88	23.43	13.00	28.14	25.62
15035	25.334	94.09	1.26	0.43	7.10	26.76	8.67	25.38	31.68
15047	25.338	94.61	1.14	0.47	7.75	30.79	7.50	24.86	28.63
15058	25.342	94.69	1.12	0.05	7.79	29.47	5.87	23.50	33.32
15069	25.346	94.24	1.23	0.22	7.35	28.29	5.73	21.47	36.95
15081	25.351	93.86	1.31	0.42	7.20	27.43	4.97	20.36	39.62
15092	25.357	93.33	1.43	0.79	7.37	25.96	5.94	21.14	38.79
15103	25.362	94.10	1.26	0.80	6.87	20.15	5.94	22.23	44.01
15115	25.366	94.66	1.13	0.80	7.18	22.73	6.05	26.59	36.65
15126	25.370	94.92	1.07	0.63	7.56	27.38	4.80	26.74	32.90
15137	25.374	94.86	1.08	0.48	7.94	28.24	3.44	25.52	34.38

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
15149	25.378	94.80	1.10	0.46	8.04	27.67	2.46	27.13	34.23
15160	25.382	94.88	1.08	0.99	8.13	28.85	5.29	26.73	30.01
15172	25.386	94.71	1.12	1.20	8.57	28.84	3.45	24.14	33.79
15183	25.390	95.03	1.05	1.20	8.81	28.53	3.45	27.95	30.06
15195	25.395	95.22	1.00	1.48	10.02	29.70	2.83	24.96	31.00
15206	25.398	96.02	0.83	1.12	9.87	31.75	3.49	23.32	30.45
15217	25.401	95.47	0.95	0.55	10.47	31.75	2.71	21.68	32.83
15229	25.404	95.53	0.94	0.33	9.89	32.70	2.71	25.54	28.82
15240	25.408	94.66	1.13	0.54	9.44	29.16	3.76	23.11	34.00
15252	25.413	94.86	1.08	0.20	7.92	30.55	3.76	28.87	28.70
15263	25.417	94.57	1.15	0.24	7.95	29.17	3.10	30.80	28.74
15275	25.421	94.57	1.15	0.24	6.86	27.21	3.79	31.91	30.00
15286	25.425	93.98	1.28	0.24	6.80	22.49	7.01	30.02	33.45
15298	25.431	93.67	1.35	0.49	6.50	23.01	5.96	31.85	32.19
15309	25.436	93.60	1.37	0.75	6.39	20.30	7.06	30.49	35.01
15321	25.441	93.99	1.28	0.85	6.25	20.35	8.16	29.58	34.81
15332	25.446	93.98	1.28	1.03	6.79	25.08	7.70	27.49	31.92
15344	25.451	94.11	1.25	1.97	7.03	26.75	4.87	28.77	30.60
15355	25.455	94.41	1.19	1.52	7.36	29.04	4.87	25.42	31.79
15367	25.460	92.76	1.58	1.60	8.05	27.54	4.33	28.79	29.70
15378	25.466	93.23	1.48	1.49	8.26	26.69	3.69	27.88	31.98
15390	25.473	93.28	1.46	1.31	8.28	22.30	1.41	30.85	35.85
15401	25.476	95.23	1.00	0.37	9.40	28.59	3.08	28.59	29.99
15413	25.480	95.61	0.92	1.68	9.57	26.58	3.08	27.63	31.47
15424	25.484	95.85	0.87	1.34	8.89	28.28	4.10	23.01	34.37
15436	25.486	95.53	0.94	2.62	9.66	32.59	4.10	23.97	27.07
15447	25.490	95.36	0.98	2.62	10.30	35.69	7.15	24.29	19.95
15459	25.495	95.63	0.92	3.59	9.75	29.26	7.24	24.88	25.26
15470	25.497	96.45	0.74	3.13	9.46	30.95	8.95	26.12	21.39
15482	25.500	96.04	0.83	3.64	9.60	30.29	10.04	27.07	19.36
15493	25.503	95.30	0.99	2.34	8.95	28.66	14.03	26.53	19.49
15505	25.508	95.00	1.05	2.87	8.02	25.11	14.47	25.46	24.08
15517	25.512	94.38	1.19	1.89	7.46	25.80	12.31	23.60	28.93
15528	25.516	94.41	1.18	1.04	8.17	24.45	12.64	25.84	27.86
15540	25.521	94.78	1.11	0.53	8.05	23.39	11.89	26.97	29.18
15551	25.525	95.00	1.06	0.53	8.01	22.27	9.42	28.54	31.22
15563	25.529	95.31	0.99	0.00	8.15	23.93	8.63	29.55	29.74

---	---	Tracer	Offgas Flow and Concentrations without tracers and water						
Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
15575	25.533	94.84	1.09	0.36	8.21	25.02	11.58	29.10	25.73
15586	25.537	95.24	1.00	0.73	7.40	26.15	13.72	27.00	25.00
15598	25.541	94.79	1.10	0.73	7.46	26.51	16.16	25.57	23.57
15609	25.545	94.69	1.12	1.28	7.32	24.48	14.18	26.40	26.34
15621	25.549	94.52	1.16	1.28	7.40	22.10	11.79	25.30	32.13
15633	25.554	95.15	1.02	0.92	7.12	20.00	10.01	25.60	36.35
15644	25.557	95.44	0.96	1.70	7.65	19.46	10.78	26.94	33.48
15656	25.561	95.78	0.88	2.53	8.08	21.08	8.52	28.99	30.80
15668	25.564	95.86	0.86	1.99	8.29	22.85	9.66	29.89	27.32
15679	25.567	95.90	0.86	2.59	8.26	27.61	10.04	34.15	17.35
15691	25.571	95.63	0.91	2.59	8.51	31.16	9.55	34.09	14.09
15703	25.575	95.49	0.94	1.44	8.07	28.92	4.61	34.20	22.76
15714	25.578	95.33	0.98	1.20	7.49	28.19	4.94	33.18	25.00
15726	25.582	95.10	1.03	1.20	7.36	29.66	5.59	26.53	29.67
15738	25.586	95.04	1.04	0.59	7.50	27.80	6.75	25.18	32.17
15749	25.590	95.17	1.02	0.88	7.21	24.61	7.08	30.21	30.00
15761	25.594	95.44	0.95	1.39	7.24	28.48	7.08	29.61	26.20
15773	25.597	95.43	0.96	1.40	8.39	27.81	6.49	32.52	23.40
15784	25.601	95.94	0.85	3.42	8.81	24.75	5.87	36.68	20.47
15796	25.604	96.35	0.76	3.42	8.79	23.52	4.01	36.51	23.76
15808	25.607	96.51	0.72	3.27	9.05	24.00	4.35	33.37	25.97
15820	25.610	96.10	0.81	4.53	8.65	19.29	5.83	34.14	27.56
15831	25.613	95.43	0.96	3.93	7.08	17.66	4.01	32.44	34.88
15843	25.617	94.82	1.09	2.27	6.54	17.89	4.72	36.47	32.11
15855	25.622	94.75	1.11	2.27	6.12	19.20	9.64	32.50	30.26
15867	25.626	94.78	1.10	2.14	6.59	21.15	9.93	26.53	33.66
15878	25.630	95.47	0.95	0.47	6.87	23.38	8.45	26.04	34.79
15890	25.633	95.40	0.96	0.47	8.01	30.33	8.45	28.44	24.30
15902	25.637	96.28	0.77	0.15	7.66	30.04	7.06	23.24	31.84
15914	25.640	95.52	0.94	0.85	8.47	28.07	2.14	22.45	38.02
15925	25.643	95.95	0.85	0.85	8.73	28.17	4.40	30.39	27.47
15937	25.647	95.97	0.84	2.40	9.11	28.34	6.18	31.81	22.16
15949	25.650	96.62	0.70	2.40	8.86	24.07	6.73	25.99	31.95
15961	25.652	96.44	0.74	2.35	9.72	22.74	8.69	25.43	31.07
15972	25.655	96.32	0.76	2.21	9.41	24.08	8.69	31.12	24.48
15984	25.658	96.43	0.74	2.21	9.23	22.88	6.82	28.26	30.60
15996	25.661	96.71	0.68	1.38	8.77	24.34	7.60	27.06	30.85

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
16008	25.664	96.04	0.83	1.38	8.96	26.65	9.78	32.18	21.05
16020	25.667	96.08	0.82	2.68	8.82	27.34	7.33	32.74	21.10
16032	25.671	95.95	0.85	4.87	8.80	26.38	11.10	32.35	16.49
16043	25.673	96.39	0.75	4.87	7.71	23.96	12.53	34.13	16.80
16055	25.676	95.70	0.90	4.04	8.26	26.12	10.47	33.21	17.90
16067	25.680	95.75	0.89	4.04	7.74	22.74	11.15	26.26	28.07
16079	25.684	95.62	0.92	2.78	7.46	24.67	15.42	29.44	20.23
16091	25.687	96.01	0.83	0.26	6.94	24.38	17.59	26.57	24.26
16103	25.691	95.32	0.98	3.18	8.33	24.56	16.55	25.58	21.80
16114	25.694	95.76	0.89	3.55	7.50	17.68	22.08	24.36	24.83
16126	25.698	95.28	1.00	3.55	8.65	21.31	20.04	31.81	14.65
16138	25.701	96.24	0.79	4.04	8.68	18.75	16.97	29.43	22.13
16150	25.705	95.94	0.85	3.82	9.64	18.37	16.62	32.49	19.06
16162	25.707	96.92	0.64	0.90	9.18	18.62	19.93	36.30	15.08
16174	25.710	96.75	0.67	0.85	9.84	19.99	20.33	40.56	8.43
16186	25.713	96.99	0.62	1.73	8.90	17.99	22.17	34.28	14.94
16198	25.715	96.70	0.68	1.30	8.47	16.10	25.15	33.74	15.24
16210	25.718	96.31	0.77	1.37	8.61	19.72	24.54	31.47	14.29
16221	25.721	96.38	0.75	2.22	7.72	21.79	23.66	26.04	18.57
16234	25.724	95.91	0.85	2.15	7.34	20.52	18.74	28.09	23.17
16245	25.727	95.90	0.86	1.28	7.06	21.01	18.51	29.22	22.92
16257	25.731	95.47	0.95	2.46	7.38	19.34	15.82	29.73	25.28
16269	25.734	95.83	0.87	2.39	7.74	16.18	13.19	33.66	26.84
16281	25.738	96.46	0.74	1.54	8.15	15.36	10.34	36.99	27.62
16293	25.741	96.51	0.73	1.29	9.04	16.65	12.09	35.41	25.53
16305	25.743	97.03	0.61	1.66	9.28	15.16	12.02	37.77	24.12
16317	25.746	96.43	0.74	0.65	9.80	16.69	13.44	42.17	17.25
16329	25.749	96.92	0.64	1.02	8.46	16.45	12.77	39.30	22.01
16341	25.751	96.31	0.77	1.28	8.99	18.49	10.78	40.04	20.42
16353	25.754	96.81	0.66	1.28	8.84	17.54	14.53	39.90	17.92
16365	25.757	96.73	0.68	1.04	8.75	18.98	11.61	41.86	17.77
16377	25.759	96.98	0.62	1.49	9.24	19.84	13.73	41.21	14.50
16389	25.762	97.01	0.62	1.78	9.41	21.62	15.57	43.43	8.18
16401	25.764	96.63	0.70	2.86	9.06	20.55	16.98	45.85	4.70
16413	25.767	96.77	0.67	2.86	8.08	21.81	12.55	48.53	6.17
16425	25.770	96.08	0.82	3.61	8.37	24.46	13.77	48.33	1.47
16437	25.773	96.30	0.77	2.86	7.10	30.60	11.59	46.37	1.47

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Cumulative Reaction Time	Est. U Conc.	CO_2 and CO	Total Offgas Flow	H_2	NO_2	N_2	O_2	N_2O	NO
(sec)	(g/L)	(vol %)	(cm^3/min)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)	(vol %)
16449	25.776	96.20	0.79	3.31	6.75	30.43	9.40	42.60	7.51
16461	25.779	96.15	0.80	2.42	6.39	31.62	13.17	33.73	12.66
16473	25.783	95.93	0.85	2.42	6.53	31.15	13.06	30.48	16.36
16485	25.786	95.75	0.89	2.06	6.89	31.92	13.52	28.17	17.43
16497	25.789	96.52	0.72	2.06	6.77	27.01	12.66	28.03	23.47
16509	25.792	96.19	0.79	0.95	7.64	29.55	14.84	29.58	17.43
16521	25.795	96.72	0.68	0.51	7.46	26.13	12.92	39.48	13.50
16533	25.798	96.06	0.82	1.64	7.59	25.35	13.99	39.30	12.14
16545	25.801	96.40	0.75	1.68	6.56	18.03	14.30	46.34	13.10
16558	25.805	95.55	0.93	1.68	6.09	18.21	16.09	45.24	12.69
16570	25.808	94.83	1.09	2.53	5.62	14.00	14.59	41.31	21.95
16582	25.813	95.08	1.04	2.53	6.27	16.05	11.77	36.85	26.54
16594	25.817	95.91	0.86	2.13	6.13	16.89	8.22	36.38	30.25
16606	25.820	96.72	0.68	1.89	6.62	20.31	12.54	30.44	28.21
16618	25.822	96.63	0.70	3.15	7.36	22.40	11.99	32.52	22.58
16630	25.825	96.27	0.76	2.40	6.52	20.84	9.96	32.64	27.63