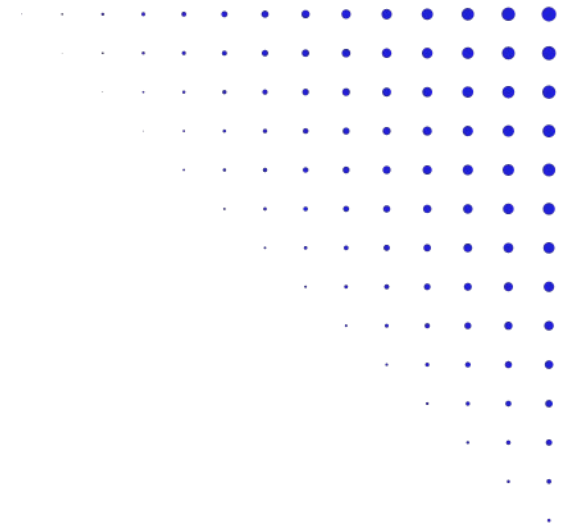




Reworld Tulsa
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November 27, 2024

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Subject: Reworld Tulsa RMW Permit Application, 2014-1722-TV (M-2)
Response to Air Quality Division Notice of Deficiency dated June 6, 2024

Reworld Tulsa RMW Solid Waste Permit No. 3572033
Response to Land Protection Division Notice of Deficiency dated June 27, 2024

Dear Ms. Yue and Ms. Young:

Reworld Tulsa (formerly "Covanta") appreciates the Oklahoma Department of Environmental Quality's ("ODEQ" or "Division") review of Reworld's respective permit modification applications for the addition of Regulated Medical Waste ("RMW") as an allowable fuel at the Tulsa facility. The proposed limit of RMW fuel at the Reworld facility is 40,000 tons/year which represents less than 10% of the permitted capacity of the facility. The Oklahoma Administrative Code (OAC) 252:100-17 uses the term "biomedical waste" instead of "regulated medical waste." Both terms refer to wastes which are generated in healthcare settings. Within this response, Reworld Tulsa uses the term "regulated medical waste" or "RMW."

The facility has operated successfully since the 1980s when the facility was first permitted by the Oklahoma Department of Health, i.e., prior to the ODEQ's formation as an agency. Ultimately, the ODEQ transitioned to become the permitting agency with the Land Protection Division being responsible for permitting of the facility's acceptance of waste materials and the conversion of those materials into useful energy and ash, and the Air Quality Division being responsible for the permitting of air emissions, including for applicable sections of New Source Performance Standards ("NSPS") issued from the United States Environmental Protection Agency ("USEPA").

The combustion of RMW at the Tulsa Facility has implications to regulations administered by both the Land Protection and Air Quality divisions, respectively. Because of this, Reworld is responding to the Notices of Deficiencies received from Land Protection and Air Quality in a single document. It is important to note that many of the items noted are only “deficiencies” because of the Divisions’ interpretation of certain Oklahoma Administrative Code (OAC) regulations as applicable to municipal waste combustors (“MWCs”) even though they were expressly written for different technology - medical waste incinerators - at a time when that type of equipment was the only option considered for treating RMW.

Within the Land Protection Division OAC 252:515-23 regulations, subparagraph 252:515-23-4(a)(4) allows treatment of RMW by “any other treatment method demonstrated to be effective in consistently achieving microbial inactivation.” Yet the Land Protection Division has determined that the Tulsa facility should be considered an incinerator under 252:515-23-4(a)(1) and further under Part 5 of Subchapter 23. This Part 5 clearly envisions an “incinerator” as a two-chamber system, typically batch-fed, in which the intent is to volatilize material from the feed stock in the primary chamber and then provide additional fuel to combust those volatiles in a second chamber as a control mechanism.

Municipal Waste Combustors achieve the same efficacy through an alternative technological design. In an MWC, as detailed in both the air and land protection permit applications, the combustion process occurs continuously through two zones. While these zones are different than the two-chamber design specified in the regulation, they are analogous in function and performance. MWC technology is a highly effective alternative design. In fact, it is the temperature reached and the duration maintained that ensure microbial destruction, not the presence of discrete chambers. In an MWC, the introduced waste spends a significant amount of time on the grate being exposed to extremely high temperatures, a highly effective environment for microbial inactivation and chemical destruction not exhibited in a traditional two-chamber medical waste incinerator. The municipal waste combustor is effective at microbial control; otherwise, the USEPA regulations would disallow the combustion of RMW in municipal waste combustors. Instead, the USEPA exempts from the Emission Guidelines and NSPS for Hospital, Medical Infectious Waste Incinerators (“HMIWI”) those facilities which are subject to the NSPS and Emission Guidelines (“EGs”) for Municipal Waste Combustors. Specifically, under federal regulations, the Tulsa facility is subject to Subpart Cb of 40 CFR 60, Emissions Guidelines and Compliance Times for Large Municipal Waste Combustors That are Constructed on or Before September 20, 1994.

Similarly, regarding the Air Quality regulations, the noted “deficiencies” are a result of the Division’s determination that the municipal waste combustors are subject to Part 4 of OAC 252:100-17. In 252:100-17-1.3, the regulation clearly identifies that incinerators and MWCs are distinct equipment stating, “Any incinerator or MWC subject to the requirements of any part of this subchapter that is used.....” The phrase “or MWCs” is a clear indication that an MWC is not an incinerator for the purposes of the regulation. Furthermore, the subparts of that chapter are

titled General Purpose Incinerators; Biomedical Waste Incinerators; Municipal Waste Combustors; Hospital, Medical, and Infectious Waste Incinerators (“HMIWI”); Commercial and Industrial (“C&I”) Solid Waste Incinerators, and Other Solid Waste (“SW”) Incinerator Units. The regulation correctly makes clear that the Tulsa facility is subject to the MWC subchapter. For the HMIWI Incinerators, C&I Incinerators, SW Incinerators, and General-Purpose Incinerators, Reworld’s affected status under 40 CFR 60 Subpart Cb (referenced and discussed above) explicitly makes these sections not applicable. Part 4 does not explicitly state MWCs are not subject to the subchapter, yet requiring the Tulsa facility to comply to this subchapter requires linguistic gymnastics. That is, although 252:100-17-1.3 separates incinerators and MWCs, Air Quality chooses to consider the units as an Incinerator (Subchapter 17, Part 4, Biomedical Waste Incinerator) AND as an MWC (Subchapter 17, Part 5, Municipal Waste Combustors). Again, similarly to the Land Protection Division regulations, Reworld is being asked to demonstrate how its MWC meets the prescriptive requirements for a distinctly different type of equipment.

OAC 252:100-17 has been updated over time to incorporate EGs and NSPS and to align Oklahoma’s regulations with federal Clean Air Act regulations. The USEPA has identified that MWCs are capable of combusting NHIW, RMW, and other waste streams, and that those facilities DO NOT ALSO have to comply with regulations written for purpose-built units like medical waste incinerators or solid waste incinerators. As such, Air Quality is attempting to regulate the Tulsa facility to a greater extent than required by federal rules.

In its application to Air Quality to modify Operating Permit Number 2014-1722-TV (M-2) to accept and process RMW as an acceptable supplemental waste, Reworld pointed out that the waste combustion units at the Tulsa facility are federally regulated as MWCs (regulations that the Air Quality Division administers within Oklahoma and that are presently incorporated as applicable requirements within the facility’s Title V Permit) and not as biomedical waste incinerators. Reworld asserted that the application to accept and process regulated medical waste should be approved as an alternative treatment method as the units provide pathogen destruction. Our application detailed that statistical analysis of stack testing results at Reworld Tulsa’s sister facilities indicate the combustion of RMW does not affect air emissions from the facility.

Even though Reworld asserts that the MWCs at Reworld Tulsa should NOT be considered as incinerators, we are responding to the Notices of Deficiency with the desire to address the requests from Air Quality and Land Protection Divisions, respectively. **Table 1** provides a summary of our responses by regulatory requirement that are explained in additional detail below.

Table 1. Summary of Air Quality & Land Protection Requirements

<u>Regulatory Citation</u>	<u>Requirement</u>	<u>Status</u>
Air Quality (OAC 252:100)		
§17-10	Biomedical waste incinerators must be designed and operated with a primary and secondary combustion chamber each of which is equipped with burners or other combustion devices that maintain the temperatures specified in subsections (1) through (3) in both the primary and secondary combustion chamber(s) when biomedical waste is being incinerated.	Municipal waste combustors achieve an equivalent level of protection using a two-zone combustion chamber. Exposure to temperatures above 2500°F and flames on the grate exceed medical waste incinerator designs.
§17-10(1)	The temperature in the primary combustion chamber of the incinerator shall not be less than 1200°F.	Temperatures at, and immediately above, the grate, in the first zone of combustion, are above 2500°F.
§17-10(2)	The temperature in the secondary combustion chamber of the incinerator shall not be less than 1800°F with a retention time of not less than 1 second when processing biomedical waste that does not include chemotherapeutic waste.	The MWC units at the Tulsa facility maintain temperatures above 1800°F for significantly longer than 1 second.
§17-10(3)	The temperature in the secondary combustion chamber of the incinerator shall not be less than 2000°F with a retention time of not less than 2 seconds when processing chemotherapeutic waste.	This requirement is not applicable since we are not proposing to handle chemotherapeutic waste. Trace amounts of chemotherapeutic constituents (less than 3%) do not render the waste as a chemotherapeutic waste, any more than trace amounts of hazardous waste constituents render a waste a hazardous waste. That said, the Tulsa MWC units achieve 2000°F for well over two seconds when the entire waste retention time is considered, inclusive of both the grate and the flue gas path.
§17-11	Establishes the emission limits for biomedical waste incinerators. Specifically: 1. Hydrochloric acid (HCl) shall not exceed 4.0 lbs/hr. 2. Particulate matter (PM) shall not exceed 0.08 gr/dscf corrected to 12% CO ₂ in the emission gas stream. 3. Carbon monoxide (CO) shall not exceed 100 ppm corrected to standard conditions.	We are proposing to meet these requirements when processing RMW as part of an alternative operating scenario included in our Title V air permit.
Land Protection (OAC 252:515)		
§23-2	OAC 252:515-23-2 defines “microbial inactivation” as a 4Log ₁₀ (99.99%) or greater reduction of an appropriate indicator organism and kill efficacy for the treatment method chosen and as approved by the DEQ.	Peer-reviewed literature and previous determinations by U.S. EPA, APHIS, and state regulators demonstrate that MWCs achieve microbial inactivation.

<u>Regulatory Citation</u>	<u>Requirement</u>	<u>Status</u>
§23-4(a)(4)	Regulated medical waste must be treated by a method demonstrated to be effective in consistently achieving microbial inactivation. A minimum temperature of 1400°F ±25°F must be maintained in the primary chamber for a sufficient time to achieve microbial destruction.	Temperatures at, and immediately above, the grate, in the first zone of combustion, are above 2500°F.
§23-51(1)	A minimum temperature of 1400°F ±25°F must be maintained in the primary chamber for a sufficient time to achieve microbial inactivation as defined in OAC 252:515-23-2.	Temperatures at, and immediately above, the grate, in the first zone of combustion, are above 2500°F.
§23-51(2)	A minimum temperature of 2000°F ±25°F must be maintained in the secondary chamber for a minimum of two seconds when processing biomedical waste.	The Tulsa MWC units achieve 2000°F for well over two seconds when the entire waste retention time is considered, inclusive of both the grate and the flue gas path.
§23-52	An incinerator must be operated such that no unburned materials are visible in the residual ash.	We will comply with this requirement.
§23-53	Incinerators must be equipped with automatic loading and protective interlocks to prevent waste from entering the secondary chamber when the temperature is below 2000°F.	The Tulsa Facility will install an interlock system that immediately stops the feed of regulated medical waste if the measured flue gas temperature drops below the value correlated to a minimum of 1800°F for a retention time of 1 second. Maintaining the correlated flue gas temperature ensures the temperature in Zone 1 where RMW enters the MWC is above 2000°F.
§23-54(a)	The incinerator design must include sample injection and collection ports to enable the Owner/Operator or DEQ to conduct periodic tests.	Variance Requested. The Tulsa facility is already subject to continuous monitoring and stack testing requirements. An important tenet of stack testing is that the testing should represent the normal operations of the unit. The facility's compliance requirements within its Air Quality permit are more restrictive than periodic testing.
§23-54(b)	Prior to operation, the owner/operator must conduct a demonstration showing complete destruction of a chemical which requires 2000°F for destruction and which is introduced into the unit under normal operating procedures.	To the extent that a demonstration must be conducted prior to operation, an independent study using a USEPA-accepted thermodynamic model demonstrates that the Tulsa Facility temperature profiles achieve greater than 99.99% destruction of monochlorobenzene, a thermally stable organic compound.

1. Design and Operation of the MWC¹

OAC 252-100-17-10 stipulates that biomedical waste incinerators be designed and operated with a primary and secondary combustion chamber each of which is equipped with burners or other combustion devices that maintain the temperatures specified in subsections (1) through (3) in both the primary and secondary combustion chamber(s) when biomedical waste is being incinerated.

In Appendix G of the application, Reworld explains that the Tulsa facility's combustion units employ a two-zone approach to waste combustion. Zone 1 extends from the grate, where waste is initially dried, ignited, and combusted, up to the elevation of the overfire air nozzles, approximately eight (8) feet above the grate. The highest temperatures in the MWC are reached in Zone 1, contributing significantly to the destruction of waste and any volatilized compounds. Zone 2 is the furnace volume above Zone 1 extending to the roof of the boiler as shown in **Figure 1**. Zone 2 provides an effective and independent mechanism for the destruction of volatile organic compounds that may be volatilized in Zone 1. Zone 2 is equipped with gas-fired auxiliary burners for start-up, shut-down and combustion control.

Primary Chamber Temperature

OAC 252-100-17-10(1) mandates that the temperature in the primary combustion chamber of the incinerator shall not be less than 1200°F.

The temperature at the surface of the waste bed in Zone 1 of the MWCs ranges between 2544°F and 2680°F, well above the required 1200°F.² **Appendix A** provides the temperature profile report of the analysis performed by Martin GmbH, the combustion designer of the Tulsa units, which serves as the basis for this temperature range.

2. Microbial Inactivation³

OAC 252:515-23-51(1) stipulates that a minimum temperature of 1400°F ±25°F be maintained in the primary chamber for a sufficient time to achieve microbial inactivation as defined in OAC 252:515-23-2. OAC 252:515-23-2 defines "microbial inactivation" as a 99.99% or greater reduction of an indicator organism as approved by the ODEQ.

As noted previously, a MWC does not have a "primary chamber" or a "secondary chamber" because it is not an "incinerator" as imagined and described in OAC 252:100-17 or OAC 252:515-23. The design and operation of the MWCs at the Tulsa facility, as supported by numerous

¹ The information provided in this response addresses the Air Quality Notice of Deficiency as to how the MWCs meet the design and operational criteria of biomedical waste incinerators at 252:100-17-10 and the minimum primary chamber temperature at 252-100-17-10(1).

² Martin GmbH, TULSA Temperature profile furnace/1. Pass, November 2024.

³ The information provided in this response addresses Land Protection Notice of Deficiency #1 with respect to the provisions of OAC 252:515-23-51-(1) and OAC 252:515-23-4(a)(4).

sources, provides a documented and accepted alternative method of achieving microbial inactivation. The elevated temperatures and retention time of the waste on the grate in Zone 1 of the Tulsa combustors are much greater than those required by OAC 252:100-17-10(1) and OAC 252:515-23-51(1) for an incinerator's "primary chamber" and, coupled with the temperature and retention time of the combustion gases in Zones 1 and 2, provide effective, if not superior, microbial inactivation. The temperature at the grate level in Zone 1 ranges between approximately 2544°F and 2680°F.⁴ The temperature of the combustion gas leaving Zone 1 ranges from 2280°F to 2390°F.⁵ The combustion gas then remains at elevated temperatures in Zone 2.

Each MWC unit at the Tulsa Facility is equipped with an automatic combustion control system that manages the waste feed rate to Zone 1 and the supply of combustion air to ensure proper combustion conditions in compliance with USEPA's Good Combustion Practices ("GCP").

The goals of GCP are to:⁶

- Maximize furnace destruction of organic pollutants,
- Limit the amount of particulate matter ("PM") carried out of the furnace with the flue gas, and
- Prevent the formation of polychlorinated compounds in the air quality control system.

Operation of the MWCs in accordance with the GCP is verified by three (3) continuously monitored compliance parameters: carbon monoxide emissions, furnace steam load, and the inlet temperature of the particulate matter control device. The nominal retention time of waste in Zone 1 of the Tulsa combustors is 45-60 minutes. The reciprocating grate in Zone 1 of each combustion unit tumbles the charged waste thereby exposing the waste to combustion air as the waste travels along the grate. Each grate is comprised of three (3) approximately-equally-sized regions. Waste charged to the unit is dried in the initial region, the waste is ignited and combusted in the middle region of the grate, and the third and final region of the grate functions to complete burnout of the ash before the waste is discharged to the ash quenching system.

Reworld Tulsa completed a document review related to the microbial inactivation capacity of combustion practices. Information was gathered from the National Research Council, the European Food Safety Authority, and APHIS Waste Management practices.

⁴ Martin GmbH, TULSA Temperature profile furnace/1. Pass, November 2024.

⁵ Martin GmbH, TULSA Temperature profile furnace/1. Pass, November 2024.

⁶ Kilgroe, J., W. Lanier, AND T. Alten. Development Of Good Combustion Practice For Municipal Waste Combustors. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/A-92/267.

National Research Council

MWCs, and the temperatures reached therein, have been well documented as destroying pathogens. The National Research Council (US) Committee on Hazardous Biological Substances in the Laboratory entitled *Biosafety in the Laboratory: Prudent Practices for the Handling and Disposal of Infectious Materials* states that well-designed and well-operated municipal waste combustors “can provide effective destruction of pathogens in the same way that a hospital waste incinerator does” and that “they often operate at higher temperatures and with longer residence times, thereby enhancing their effectiveness for the destruction of pathogens.”⁷ In the section of the document concerning medical waste treatment methods, the authors state that “Primary combustion temperatures of at least 1600°F with good mixing and a gaseous retention time of 2 seconds should provide for good burnout for the waste described in this chapter. All pathogens and proteinaceous materials are denatured at temperatures well below that just cited.”⁸ The waste combusted in Zone 1 of the MWCs at the Tulsa Facility is well mixed with excess oxygen, exposed to temperatures of 2500°F and higher in the middle region of the grate, and remains above 1600°F for several minutes.⁹

European Food Safety Authority

An article published in the European Food Safety Authority (EFSA) Journal in October of 2021 contains EFSA’s findings in response to a request from the European Union (EU) to assess if different thermal processes achieve a 5log₁₀ reduction in specified bacteria and a 3log₁₀ reduction in thermoresistant viruses.¹⁰ EFSA is the agency of the EU that provides independent scientific advice and communicates on existing and emerging food risks associated with the food chain. In Europe, combustion at 850°C (1562°F) for two (2) seconds is required by Annex III of Commission Regulation (EU) No 142/2011. The authors considered various biological constituents and determined “bacteria, viruses and parasites are generally sensitive to heat and cannot survive normal burning temperatures.” They further provided the following insights:

⁷ *Biosafety in the Laboratory: Prudent Practices for the Handling and Disposal of Infectious Materials*, National Research Council (US) Hazardous Biological Substances in the Laboratory, Washington D.C. National Academics Press, 1989.

⁸ *Biosafety in the Laboratory: Prudent Practices for the Handling and Disposal of Infectious Materials*, National Research Council (US) Hazardous Biological Substances in the Laboratory, Washington D.C. National Academics Press, 1989.

⁹ Martin GmbH, TULSA Temperature profile furnace/1. Pass, November 2024.

¹⁰ “Inactivation of indicator microorganisms and biological hazards by standard and/or alternative processing methods in Category 2 and 3 animal by-products and derived products to be used as organic fertilisers (*sic*) and/or soil improvers.” EFSA Panel on Biological Hazards, EFSA Journal, 20 October 2021.

Bacterial Indicators	Condition	Study Criteria of 5log10
<i>Enterococcus faecalis</i>	Two seconds at temperatures in excess of 98°C (208°F)	Greater than a 5log10 reduction
<i>S. Senftenberg 775W</i>	Two seconds at temperatures in excess of 74°C(165°F)	Greater than a 5log10 reduction
Thermoresistant Virus Indicator		Study Criteria of 3log10
Parvovirus	<i>“For viruses, from the data presented it is clear that at high process temperatures, the times required to achieve a 3log10 reduction in the identified viruses are significantly reduced. Multiple studies have shown a reduction of over 3log10 of parvovirus within short time periods, for example, Nims and Plavsic (2013b) reported a 4log10 reduction in parvovirus in 0.5 minutes at temperatures of 101 °C, 112 °C, 117 °C in water, and 196 °C in culture media.” (page 65)</i>	

The waste combusted in the MWCs at the Tulsa facility is exposed to temperatures and retention times in excess of the conditions upon which EFSA based its conclusions. Thus, the cited work supports the microbial inactivation capacity of the Reworld Tulsa MWCs.

APHIS Waste Management

In addition to processing municipal solid waste and permitted nonhazardous industrial wastes, Animal and Plant Health Inspection Service waste (“APHIS Waste”) is received and processed at 18 of Reworld’s MWC facilities under agreements with the United States Department of Agriculture (USDA). APHIS Waste includes all waste material derived wholly or in part from fruits, vegetables, meats or other plants or animals (including poultry material), and other refuse of any character that has been associated with any such materials. The facilities receive and process this waste from incoming international air flights and cruise ships and from confiscated imported plant and animal waste that does not pass USDA inspection. Reworld is an APHIS partner because of its ability to effectively destroy these wastes to protect agriculture and natural resources from the introduction of plant and animal pests and diseases, including viruses like avian flu and COVID.

The design and operation of the MWC units at the Tulsa facility, the long-standing implementation of Good Combustion Practices in the operation of the combustion units, and the effectiveness of the air quality control systems at the facility qualify the technology as an effective means for the disposal of RMW. Reworld has more than 30 years of experience in combusting RMW with municipal solid waste and other nonhazardous wastes at its facilities in Oregon, Florida, and Alabama. Other regulatory agencies have recognized MWCs as an approved means of managing RMW.

3. Secondary Chamber Temperature¹¹

Secondary Chamber Temperature – Air Quality

OAC 252-100-17-10(2) mandates that the temperature in the secondary combustion chamber of the incinerator shall not be less than 1800°F with a retention time of not less than 1 second when processing biomedical waste that does not include chemotherapeutic waste.

OAC 252:100-17-10(3) requires that the temperature in the secondary combustion chamber of the incinerator shall not be less than 2000°F with a retention time of not less than 2 seconds when processing chemotherapeutic waste.

Secondary Chamber Temperature – Land Protection

OAC 252:515-23-51(2) stipulates that a minimum temperature of 2000°F \pm 25°F be maintained in the secondary chamber for a minimum of two seconds when processing biomedical waste.

OAC 252:515-23-53 requires that incinerators must be equipped with automatic loading and protective interlocks to prevent waste from entering the secondary chamber when the temperature is below 2000°F.

Waste processed in the MWCs at the Tulsa Facility is exposed to temperatures above 2500°F at grate level and to temperatures of at least 2000°F for well over 2 seconds, inclusive of 2 seconds in the flue gas path and minutes on the grate. These temperatures and durations are well in excess of Oklahoma’s regulatory requirements.

Martin GmbH (“Martin”), the designer of the MWCs at the Tulsa Facility, conducted a temperature profile study of one of the units at the Tulsa facility using design data, temperature measurements of the flue gas in the upper furnace using Infrared Pyrometer technology (“IR technology”), and overfire and underfire air flow data along with other operating data including the oxygen concentration of the flue gas.¹² The design and operating data allowed Martin to determine the temperature at grate level. Martin determined the time and temperature profiles at five different boiler thermal load points based on the waste feed rate and higher heating value of the waste as described in its report. Models A, B, and C reflect operation at full load. Models D and E are based on less than full load. Models A through E reflect the full range of scenarios that reflect typical operations.

In accordance with Reworld’s standard operating procedures, RMW will not be fed to an MWC within four (4) hours following the start-up of a unit to ensure that optimum combustion conditions have been established. Similarly, RMW will not be charged to a unit within four (4)

¹¹ The information provided in this Response addresses Air Quality Notice of Deficiency #2 and Land Protection Notice of Deficiencies #2 and #5 as to how the MWCs meet the temperature and retention time criteria for biomedical waste incinerators at 252:100-17-10(2) and 252-100-17-10(3), and the minimum secondary chamber temperature and retention time criteria at OAC 252:515-23-51(2) and OAC 252515-23-53.

¹² Martin GmbH, TULSA Temperature profile furnace/1. Pass, November 2024.

hours prior to a planned shutdown of the unit to ensure combustion of all waste has been completed. The results of the engineering calculations for the full load cases (Models A–C) showed grate level temperatures of from 2544°F to 2630°F.

The design and operating data also provided Martin with the ability to calculate the temperature and the cumulative residence time of the flue gas at different elevations within Zone 2 and the residence time of the combustion gases at selected temperatures. **Figure 1** details the findings from the Martin study. The combustion gas temperature leaving Zone 1 at 8 feet above grate level ranged from 2280°F to 2390°F. Across the models at full load (Models A through C), the total flue gas retention time above 2000°F within the accepted uncertainty range of $\pm 25^\circ\text{F}$, was calculated at 1.8-2.1 seconds – meeting the 2 second retention time requirement. In addition to these flue gas temperatures and residence times, the waste has several minutes of exposure to temperatures in the 2544°F-2630°F range while in the center zone of the grate. Thus, the engineering calculations and the site correlation study demonstrate compliance with the temperature and retention time requirements in ODEQ’s Land Protection and Air Quality regulations. A copy of Martin’s report of the temperature correlation study is contained in **Appendix A**.

As described above, waste fed into the MWC has a retention time of 45-60 minutes on the grate, depending on the speed of the grate. During a portion of this time, estimated to be at least 10 minutes,¹³ the waste is exposed to the highest temperatures in the boiler – temperatures above 2500°F. The extreme heat and flames at the grate result in direct combustion, gasification of organic molecules to intermediaries like carbon monoxide (CO), hydrogen (H₂) and methane (CH₄), and volatilization of compounds in the waste. Furthermore, the integration of waste directly into a flame has additional destructive properties beyond what would normally result from temperature alone. Flames result in the production of free radicals, which greatly accelerate the rate of chemical reactions associated with the decomposition of organics in the waste.¹⁴

The products of the initial combustion are then carried into the area above the grate as flue gases and exposed to an additional high-temperature retention time. The units maintain the flue gases at a temperature of 2000°F for two (2) seconds across a range of operating scenarios evaluated by the original equipment manufacturer, Martin, based on the design of the units and actual operating data collected from the MWC units at the Tulsa facility. This two-second flue gas retention time alone meets the provisions of both OAC 252:515-23-53 and OAC 252:515-23-51(2), even without the inclusion of the significant retention time on the grate.

The combination of the retention time on the grate and within the flue gas path provides the most accurate picture of the total retention time above 2000°F. Because medical waste

¹³ Time estimate is based the aforementioned grate regions of which the center third of the grate along its length of travel from waste injection to ash discharging is the predominate area of combustion.

¹⁴ Wilson, Jr., W.E. and R.M. Fristrom (1963) Radicals in Flames, *APL Technical Digest*, July – August 1963. <https://secwww.jhuapl.edu/techdigest/content/techdigest/pdf/APL-V02-N06/APL-02-06-Wilson.pdf>

incinerators operate in the starved air configuration in the primary chamber, they are not designed to reach the elevated temperatures that MWCs reach near the grate. Therefore, to logically compare the Tulsa MWC units against the 2000°F temperature requirements of both Land Protection and Air Quality, ODEQ must consider the entire time that waste is exposed to temperatures greater than 2000°F. It is the combination of the retention time on both the grate and within the flue gas path that provides the most accurate picture of the total retention time above a reference temperature to which the waste is exposed. On this basis, the MWC units at Tulsa provide well over 2 seconds of retention time over 2000°F.

In summary, the Martin temperature profile analysis concludes that RMW would be exposed to temperatures in excess of 2500°F at grate level and that the flue gas from the combustion process would be exposed to a temperature of 2000°F for two (2) seconds. These factors combine to demonstrate compliance with ODEQ's temperature and residence time requirements for processing RMW. The temperatures and combustion conditions are higher and longer than those experienced in traditional medical waste incinerators.

Feed System Interlock

Oklahoma's regulations at OAC 252:515-23-53 require the operation of interlocks to prevent regulated medical waste from being introduced when temperatures in the secondary chamber of an incinerator are below 2000°F. It is necessary to continuously monitor temperature at an appropriate location in the MWC to implement the required feed system interlock. Given it is not technically possible to reliably monitor the extremely high temperatures of the RMW and flue gas at grate level, Reworld proposes to establish a flue gas temperature limit in the upper furnace of each combustor which will serve as the basis for interlocking the RMW feed system, as was done at its Lake County and Marion County facilities where Reworld processes RMW. Compliance with the upper furnace temperature limit will be determined by continuous flue gas temperature monitoring at the elevation of the existing Infrared Pyrometers, at elevation 70 feet (40 feet above grate level) as shown on **Figure 1** and in the Martin report (**Appendix A**). Reworld will install an electrical interlock system between that upper furnace temperature (monitored using the IR Pyrometers) and the RMW feed system so that any time the upper furnace temperature falls below the established limit, the RMW feed system will cease operation until the upper furnace temperature is above the required temperature. This proposed approach will ensure continuous compliance with the temperature/retention time requirements of the regulations.

Reworld proposes a 1-hour average flue gas temperature limit of 1429°F at 40 feet above grate level as the minimum temperature limit below which the RMW feed system interlock will be activated.

The proposed 1429°F limit ensures:

1. A flue gas temperature of 1800°F for a retention time of one (1) second to meet OAC 252-100-17-10(2); and
2. A minimum temperature at the grate of 2000°F to meet the requirement to stop delivery of RMW if temperatures are below 2000°F (OAC 252; 515-23-53); and
3. A total retention time above 2000°F of more than 2 seconds, inclusive of both the grate and flue gas path to meet the requirements of OAC 252: 515-23-51(2) and OAC 252:100-17-10(3).

The proposed limit is calculated based on the temperature profiles established by Martin, the original equipment manufacturer, that relied on actual operating data collected at the Tulsa facility. The monitored temperature at the IR Pyrometer elevation was correlated to temperatures in the furnace at specific elevations and resultant retention times based on boiler geometry, air flow rates, and grate speeds to ensure the three conditions above are met.

The result of the correlation indicates that an IR Pyrometer flue gas temperature of 1429°F correlates with ensuring a flue gas retention time of at least one (1) second at 1800°F. To determine the correlation value, we used Martin's Model condition "E", which reflects the lower end of scenarios that reflect typical operations. In Model "E", the one second retention time is met at an elevation of 13.6 feet above the grate, at a temperature of 2234°F, with a temperature margin of 434°F. Martin's models, including Model E, are based on actual operating data, including measured temperatures at the existing IR Pyrometers located 40 feet above grate level of 1863°F. Subtracting the same temperature margin of 434°F from Martin's model from the measured temperature of 1863°F yields the value of 1429°F. This ensures we have a *minimum* of 1 second of retention time at 1800°F.

Maintaining the minimum flue gas temperature of 1429°F at the IR Pyrometer level also ensures that RMW will be charged to Zone 1 when the grate level temperature is greater than 2000°F. As described previously, the minutes of exposure of the waste on the grate above 2000°F and the retention time of the flue gas at temperatures in excess of 2000°F will combine, resulting in a retention time exceeding two (2) seconds at a minimum temperature of 2000°F. It is on this basis that Reworld proposes a flue gas temperature of 1429°F on a 1-hour average basis, as measured using the existing IR Pyrometers located 40 feet above grate level, as the limit at which the RMW feed system interlock will activate in compliance with OAC 252:515-23-53.

Chemotherapeutic Waste

Regarding chemotherapeutic waste, Reworld has proposed trace chemotherapeutic waste (less than or equal to 3% by weight chemotherapeutic waste) as acceptable RMW for processing at the Tulsa facility and, importantly, has specified in its Air Quality and Land Protection permit applications that bulk chemotherapeutic waste will be unacceptable for receipt and processing at the Tulsa facility. This approach is consistent with how these wastes are managed at the other

facilities at which Reworld processes RMW and is in accordance with the federal Resource Conservation and Recovery Act (RCRA) (40 CFR Parts 239-279).

Trace chemotherapy waste usually includes vials, bags, IV tubes and other items that are used to contain chemotherapy drugs and stored in yellow RCRA containers at medical facilities. Under RCRA, trace chemotherapeutic waste is defined as waste containing less than three (3) percent chemotherapeutic agents by weight (such containers and waste items are referred to as being "RCRA-empty") and can be managed as regulated medical waste. Combustion is recommended for disposal. Conversely, bulk chemotherapeutic waste, waste containing greater than three (3) percent by weight chemotherapeutic agents, is regulated as hazardous waste, and stored in black RCRA containers at medical facilities. It cannot and will not be received and processed at the Tulsa facility. Reworld's experience at its other RMW facilities suggests trace chemotherapeutic wastes are typically less than 1% of the RMW waste stream. Further, trace chemotherapeutic waste is already present in the existing municipal waste stream which can and does contain home-health care related wastes.

The information provided in this section related to temperature profiles within the MWCs demonstrates that Reworld Tulsa meets the requirements of OAC 252:100-17-10(3). Further, trace chemotherapeutic wastes ("RCRA-empty") are appropriately considered as RMW rather than as chemotherapeutic wastes.

4. Periodic Testing¹⁵

OAC 252:515-23-54(a) requires the incinerator design to include sample injection and collection ports to enable the Owner/Operator or DEQ to conduct periodic tests.

OAC 252:515-23-54(b): Prior to operation, the owner/operator must conduct a demonstration showing complete destruction of a chemical which requires 2000°F for destruction and which is introduced into the unit under normal operating procedures.

Reworld's exhaust stacks already include sample ports for periodic testing. The facility is subject to annual stack testing requirements for numerous compounds. These ports are used by the Owner/Operator to demonstrate compliance with its air quality permit limits. The sample ports are available to ODEQ as required in OAC 252:100-43-3. Regarding Land Protection's requirement for sample injection ports, a cornerstone of stack testing is that it represents normal operating conditions. If ODEQ Land Protection would like to conduct its own tests of the unit's operations, Reworld would suggest the compound to be studied should be introduced in the same manner as for normal operations – i.e., in a vial, an IV bag, a bandage, etc.

¹⁵ The information provided in this response addresses Land Protection Notice of Deficiency #4 which concerns sample and collection ports and Land Protection Notice of Deficiency #5 which pertains to conducting a demonstration test of a chemical.

Reworld appreciates the expertise related to stack testing that is found within the Air Quality Division and recommends that any requirements related to monitoring and stack testing be included within the Air Permit rather than within the Land Protection permit. For completeness, please note that Reworld is subject to the following continuous emission monitoring and stack testing requirements:

- Good combustion practices, as defined by the USEPA, are continuously monitored and include the concentrations of carbon monoxide and oxygen in the flue gas, the steam production rate, temperature at the inlet of the fabric filters, and the feed rate of activated carbon to the flue gas.
- The stack concentrations of sulfur dioxide, nitrogen oxides and opacity in the flue gas are also continuously monitored along with many operational parameters.
- Manual stack testing using USEPA Reference Methods are conducted annually for the emissions of particulate matter, hydrogen chloride, volatile organic compounds, cadmium, lead, mercury, and dioxins/furans.

As described above, Reworld proposes to continuously monitor the temperature of the flue gas in the upper furnace region to parametrically demonstrate compliance with the temperature and retention time requirements when combusting RMW.

Each MWC unit will be equipped with an interlock between the upper furnace temperature monitor and automatic RMW feed system such that the addition of RMW will be prevented if the upper furnace temperature drops below the established temperature limit. The combination of the continuous monitoring of emission concentrations, operational parameters, and the emissions testing provisions required by the Title V air permit for the facility, document the environmental performance achieved at the Tulsa facility. Reworld anticipates that when combusting RMW the Title V permit will require additional specific requirements including continuous monitoring of the flue gas temperature in the upper furnace as well as the feed interlock system.

Reworld asserts that continuously demonstrating compliance with the many operational parameters and emission limits contained in the Title V permit provides greater environmental protection than a single test requirement as envisioned in Land Protection's regulations. As per our Land Protection and Air Quality permit applications to process RMW at the Tulsa Facility, emissions from our similar facilities at which RMW is processed are well below permitted levels, and emissions are not impacted due to combusting RMW. We expect the same to be true in Tulsa.

Organic Destruction Test

The design of the MWCs at the Tulsa Facility do not safely lend themselves to adding sample injection and collection points, nor would such injection/collection ports be representative of the unit's operation. Reworld commissioned Dr. Phillip Taylor, a recognized expert in the field of waste combustion, to perform destruction removal efficiency calculations of a thermally stable organic

compound in the MWCs at Tulsa using the Thermal Stability Ranking model developed by the University of Dayton Research Institute for the USEPA. For the MWCs at Tulsa, Dr. Taylor used the design temperature profile, plant operating data, and the previously discussed temperature profile study as inputs to the Thermal Stability Ranking model and to thereby predict the destruction removal efficiency of monochlorobenzene, a highly stable organic compound. The result of the model indicates that the destruction removal efficiency of monochlorobenzene exceeds 99.99%. A report detailing Dr. Taylor's methodology and conclusions will be submitted under separate cover.

5. Air Quality Control System¹⁶

Although not specifically designed for pathogen destruction, each MWC unit at the Tulsa facility is equipped with 1) an advanced combustion control system to regulate waste feed and the flow of underfire and overfire combustion air, and 2) an effective air quality control system. The combustion control systems provide for efficient combustion of the waste charged to the MWC units as it travels along the reciprocating grate, which mixes the waste and exposes it to oxygen contained in the underfire and overfire air. Each MWC is also equipped with a gas-fired auxiliary burner used to preheat the furnace during unit startups and, when necessary, to maintain Good Combustion Practices based on monitored CO concentrations. The air quality control system of each MWC consists of a selective non-catalytic reduction system to control the emissions of nitrogen oxides, an activated carbon injection system for reducing the emissions of organic compounds and mercury, a lime spray dry scrubber for the control of acidic gas emissions, and a fabric filter for the control of particulate matter. These air quality control systems combine to minimize the emissions of pollutants generated by the combustion of the waste in the MWCs.

As shown in the Land Protection and Air Quality permit applications, emissions from the MWCs at Tulsa are well below permitted levels. Concerning the emissions of organic substances: since 2020 the annual emission test result of volatile organic compounds has averaged 0.14 pounds per hour (lbs/hr) versus the permit-allowable limit 2.3 lbs/hr. Over the same period the emissions of polychlorinated dibenzo-p-dioxins and dibenzofurans, difficult to destroy organic substances, have averaged 0.68 nanograms per dry standard cubic meter corrected to 7% oxygen (ng/dscm@7%O₂) versus the permit-allowable of 30 ng/dscm@7%O₂.

The combination of the implementation of good combustion practices and the air quality control system on each MWC provides for effective control of organic substance emissions from the facility.

¹⁶ The information provided in this section responds to Land Protection Notice of Deficiency #3 concerning the contribution of control systems.

6. Emission Limits

Emission Limits are only addressed within the Air Quality permit and regulation OAC 252:100-17-11. OAC 252:100-17-11 establishes the emission limits for biomedical waste incinerators. Specifically:

- Hydrochloric acid (HCl) shall not exceed 4.0 lbs/hr
- Particulate matter (PM) shall not exceed 0.08 gr/dscf corrected to 12% CO₂ in the emission gas stream
- Carbon monoxide (CO) shall not exceed 100 ppm corrected to standard conditions

The facility's existing Title V permit already addresses these pollutants. Hydrochloric acid is the only pollutant for which the emission limits in OAC 252:100-17-11 would reduce the current emission limits. The permit currently limits HCl to 29 ppmdv corrected to 7% O₂ or a reduction of 95%, whichever is less stringent. Compliance is determined during annual stack testing. The permit limits each combustion unit to 73.19 tons/year HCl. The HCl emission limit of OAC 252:100-17-11 would be a reduction of the allowable HCl from the combustors. Reworld proposes to meet the 4.0 lbs/hr when processing biomedical waste.

For Particulate Matter, the existing permit emission limits for particulate matter for each MWC as specified in the Title V permit for the facility are 0.06 gr/dscf corrected to 12% CO₂ and 25 mg/dscm corrected to 7% O₂, both of which are more stringent than the 0.08 gr/dscf corrected to 12% CO₂ limit. Compliance with the particulate matter limits will continue to be determined during annual stack testing.

For CO, the current Title V permit for the facility already limits CO to 100 ppmdv corrected to 7% O₂ which is consistent with OAC 252:100-17-11 (3).

To accommodate the addition of OAC 252:100-17 to the permit, Reworld proposes that the combustion of RMW be listed as an alternative operating scenario in its Title V permit and that when RMW is being combusted, the facility will monitor the upper furnace temperature to provide parametric data to the temperatures being experienced by the waste. Further the alternate operating scenario will establish facility emission limits for pollutants as the lesser of Specific Condition 1 or OAC 252:100-17-11. Compliance with the HCl and PM limitation (when combusting RMW) will be demonstrated during stack testing (during which time the combustors will be operating between 90% and 100% of the unit's operating capacity including up to 10% RMW), and CO compliance will be demonstrated contemporaneously using the existing CO CEMS.

7. RMW Waste Charging Limit¹⁷

The statement in **Appendix B** of the permit application that the proposed permit modification will allow the facility to combust 20,000 tons per year of RMW was an error. Consistent with the narrative of the application, Reworld proposes to limit the amount of RMW processed at the Tulsa Facility to 40,000 tons per year. The total permitted waste capacity of the facility is 410,625 tons per year. The RMW material will be considered non-MSW material and will represent a portion of the non-MSW combusted at the facility which is limited to 70%. An updated **Appendix B** from the application is attached as **Appendix B**.

We look forward to your review.

Yours,



Stephanie Allois

Director, Regional Environmental
South Region



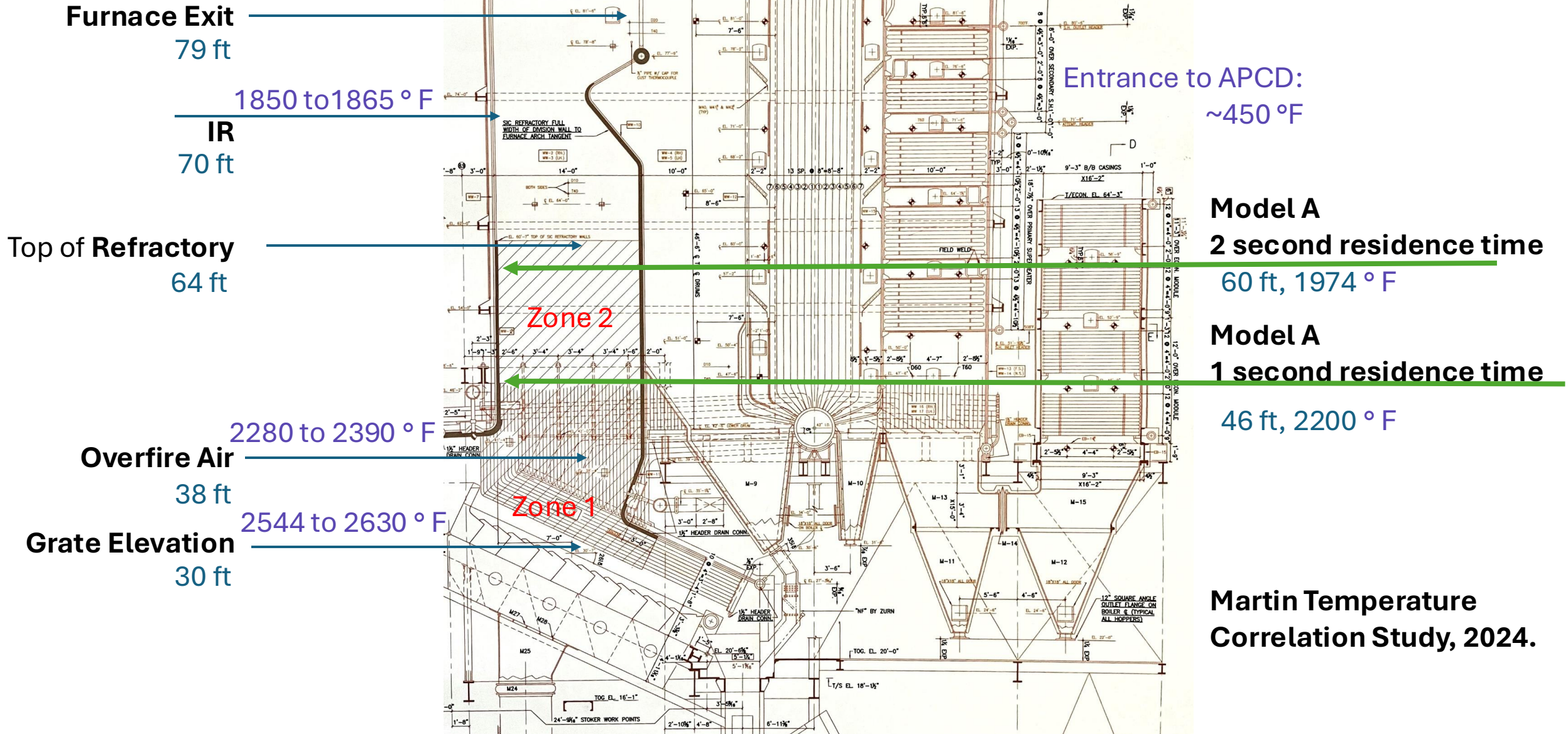
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¹⁷ The information provided in this section responds to Land Protection Notice of Deficiency #6 concerning the requested processing rate.

Figure 1



Appendix A



MARTIN

WASTE TO ENERGY – INNOVATION AUS TRADITION

TULSA

Temperature profile furnace/1. pass

AGENDA

01

Tasks and Aims

02

Input Data

03

Combustion Calculation

04

Thermal calculation

05

Results

06

Source of Literature

1. Tasks and Aims

Calculation adiabatic combustion temperature

- Creation of a model for the combustion chamber and 1st pass
- Determination of the temperature at grate level
- Determination of the elevation of 1800 °F
- Calculation of the temperature at a residence time of 2 s. Is 2000 °F/ 2 s feasible?

2. Input Data



HHV Data Summary – Jan 2024

DATA INPUTS	UNITS	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Tot/Avg
Refuse Processed	Tons	28,121.1	10,394.0	23,126.3	28,696.1	22,619.5	28,154.1	26,933.5	29,072.8	26,113.7	26,630.7	21,592.3		271,454.1
Total Operating Time - All Units	Hours	2,018.5	772.2	1,831.6	2,062.5	1,638.2	2,031.6	1,981.3	2,092.9	1,854.0	1,899.2	1,625.6		19,807.5
Boiler 1 Steam Production	klbs	64,857.8	0.0	54,738.6	63,200.1	63,673.0	68,295.7	60,194.1	67,101.0	49,040.9	60,735.0	58,789.7		610,625.9
Boiler 2 Steam Production	klbs	59,064.7	36,787.1	50,017.1	65,164.2	44,983.6	62,657.8	70,442.7	69,663.2	65,906.0	58,238.5	57,504.7		640,429.5
Boiler 3 Steam Production	klbs	70,112.3	34,933.9	54,818.0	69,656.1	47,418.3	63,305.7	55,235.7	63,835.6	65,238.1	64,779.1	37,894.0		627,226.8
Boiler 1 Stm Temp	deg F	694.5	0.0	523.0	643.6	669.1	693.0	697.2	683.6	668.9	690.6	708.0		669.0
Boiler 2 Stm Temp	deg F	684.9	589.7	519.4	633.0	618.1	621.3	650.9	684.9	669.3	651.7	692.7		642.6
Boiler 3 Stm Temp	deg F	645.1	653.1	527.5	668.3	670.3	618.3	696.9	646.5	655.8	669.9	637.8		645.0
Boiler 1 Stm Press	psig	689.1	0.0	512.1	637.9	632.4	640.0	637.9	645.8	642.6	638.2	637.1		632.9
Boiler 2 Stm Press	psig	640.0	607.2	496.2	637.1	631.7	639.9	635.2	645.4	637.8	637.4	636.5		625.3
Boiler 3 Stm Press	psig	644.6	613.3	464.4	642.3	640.9	644.5	643.0	649.3	640.6	640.1	646.9		626.2
Boiler Feedwater Temperature (Avg)	deg F	231.8	241.9	234.6	216.4	222.8	220.0	212.4	230.5	209.9	203.6	181.7		217.8
Blr 1 Econ Exit Gas Temp (Avg)	deg F	404.0	0.0	336.0	400.0	397.0	393.0	405.0	426.0	423.0	410.0	429.0		402.6
Blr 2 Econ Exit Gas Temp (Avg)	deg F	426.5	388.8	326.3	405.0	387.1	381.4	397.3	424.5	408.8	382.0	429.1		398.1
Blr 3 Econ Exit Gas Temp (Avg)	deg F	381.5	382.0	347.1	395.9	407.5	406.4	413.5	428.8	438.5	439.7	428.0		407.0
Blr 1 Heated Comb Air Temp	deg F	59.0	0.0	70.0	78.8	84.2	97.3	99.6	100.7	98.0	86.0	70.8		84.5
Blr 2 Heated Comb Air Temp	deg F	58.4	48.3	70.2	76.9	83.0	94.4	96.8	98.4	95.8	81.7	69.9		81.5
Blr 3 Heated Comb Air Temp	deg F	58.8	47.5	70.0	78.6	83.0	96.1	98.3	100.4	97.0	84.9	71.8		82.1
Ambient Air Temp (Avg)	deg F	40.0	31.3	55.7	59.6	66.5	78.9	81.1	83.1	79.0	65.8	51.9		65.2
Blr 1 Econ Exit Wet O2 (Avg)	%	9.07	0.00	13.13	10.33	10.72	12.53	9.91	10.07	10.66	9.85	9.46		10.56
Blr 2 Econ Exit Wet O2 (Avg)	%	10.51	11.08	12.30	10.28	10.49	9.92	9.56	9.51	9.20	9.66	9.75		10.11
Blr 3 Econ Exit Wet O2 (Avg)	%	11.96	12.51	12.99	11.21	11.30	11.54	11.28	11.45	11.19	11.03	11.57		11.59
Aux Fuel Usage - Natural Gas	kcuft	6,397.00	0.00	4,642.00	2,096.00	2,966.00	5,896.00	8,980.00	6,499.00	3,708.00	5,257.00	4,122.00		50,563.0
HHV Raw Database Curve	Btu/lb	5,445.5	5,327.2	5,059.6	5,495.3	5,467.8	5,429.8	5,528.2	5,451.9	5,548.9	5,581.6	5,910.7		5,482.8

2. Input Data



Process Data from 10/14/2024

Object Tree	Scale	Engineerin...	Tag	Raw Scale	Minimum	Maximum	Average	Std Deviation	Cursor1	Cursor1 Time
<input checked="" type="checkbox"/> B1 Main Steam Flow PV	0.00 - 115.00	klbs	TuIDAS.TUL_B1FT112_PV	0.000000 - 115.000000	89.0	101.0	94.0	2.3	95.5	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Boiler Feedwater PV	0.00 - 115.00	klbs	TuIDAS.TUL_B1FI114_PV	0.000000 - 115.000000	64.9	111.6	87.6	9.6	95.9	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Steam Header Press PV	500.00 - 700.00	psi	TuIDAS.TUL_B1PT118_PV	0.000000 - 1000.000000	618	626	621	1	620	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Sec SH Out Steam Temp PV	0.00 - 1,000.00	DegF	TuIDAS.TUL_B1TT117_PV	0.000000 - 1000.000000	1,000	1,000	1,000	0	1,000	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 ECON WATER INLET TEMP	0.00 - 300.00	-	TuIDAS.TUL_B1TT124_PV	-	-	-	-	-	n/a	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1_CC_Temperature_PV	1,000.00 - 2,000.00	DegF	TuIDAS.TUL_B1_CC_Temperatur...	0.000000 - 2000.000000	1,741	1,991	1,865	47	1,900	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 O2 CEMS SDA Inlet Dry Vol	5.00 - 20.00	%	TuIDAS.TU_1AE126_PV	0.000000 - 25.000000	9.3	12.2	10.9	0.5	11.1	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Total Air Flow PV	0.00 - 200,000.00	lbs/hr	TuIDAS.TUL_B1FI101_PV	0.000000 - 200000.000...	145,112	173,855	157,908	5,749	154,043	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 IR Temp Probe PV	1,000.00 - 2,000.00	DegF	TuIDAS.TUL_B1TIT_1001_PV	250.000000 - 3000.000...	1,740	1,997	1,865	47	1,900	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 FIREBOX AVG TEMP	1,000.00 - 2,000.00	DEGF	TuIDAS.TU_1TT130A_PV	0.000000 - 3000.000000	1,728	1,820	1,773	19	1,781	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 PRI SH OUTLET GAS TEMP	1,000.00 - 2,000.00	DEGF	TuIDAS.TU_1TE127E_PV	-454.000000 - 2498.00...	594	595	595	-	n/a	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 GEN BANK INLET GAS TEMP	0.00 - 2,000.00	DEGF	TuIDAS.TU_1TE127G_PV	-454.000000 - 2498.00...	1,257	1,259	1,258	-	n/a	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 FIREBOX SIDEWALL GAS TEMP	0.00 - 2,000.00	DEGF	TuIDAS.TU_1TE127I_PV	-454.000000 - 2498.00...	-	-	-	-	n/a	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 PRI SH INLET GAS TEMP	0.00 - 2,000.00	DEGF	TuIDAS.TU_1TE127K_PV	-454.000000 - 2498.00...	738	739	739	-	n/a	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Preheater Out Temp PV	0.00 - 300.00	DegF	TuIDAS.TUL_B1TT103_PV	0.000000 - 300.000000	92	97	95	1	92	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Drum Press PV	500.00 - 900.00	psi	TuIDAS.TUL_B1PT110_PV	0.000000 - 1000.000000	671	684	677	3	677	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 ECON OUTLET GAS TEMP	0.00 - 500.00	-	TuIDAS.TUL_B1TE123A_PV	-	-	-	-	-	n/a	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Side Wall Temp PV	0.00 - 3,000.00	DegF	TuIDAS.TUL_B1TT130_PV	0.000000 - 3000.000000	1,728	1,820	1,773	19	1,781	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1_OFA_Front_Press_PV	0.00 - 20.00	inwc	TuIDAS.TUL_B1_OFA_Front_Pre...	0.000000 - 99.000000	10.1	10.3	10.2	0.0	10.2	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1_OFA_Rear_Press_PV	0.00 - 20.00	inwc	TuIDAS.TUL_B1_OFA_Rear_Pre...	0.000000 - 99.000000	11.7	11.8	11.7	0.0	11.7	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 SDA INLET TEMP AVG	200.00 - 500.00	DEGF	TuIDAS.TU_1TR7000_PV	100.000000 - 600.0000...	466	479	473	3	474	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 PRI SH INLET STEAM TEMP	0.00 - 1,000.00	DEGF	TuIDAS.TU_1TE136A_PV	0.000000 - 1000.000000	582	595	589	3	589	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Prim SH Steam Outlet Temp PV	0.00 - 1,000.00	DegF	TuIDAS.TUL_B1TT115_PV	0.000000 - 1000.000000	0	0	0	0	0	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Prim SH Steam Outlet Temp PV	0.00 - 1,000.00	DegF	TuIDAS.TUL_B1TT116_PV	0.000000 - 1000.000000	582	595	589	3	589	10/14/2024 1:29:44 AM
<input checked="" type="checkbox"/> B1 Sec SH Out Steam Temp PV	0.00 - 1,000.00	DegF	TuIDAS.TUL_B1TT117_PV	0.000000 - 1000.000000	1,000	1,000	1,000	0	1,000	10/14/2024 1:29:44 AM

2. Input Data

Additional Information

Pitot measurements:

- 38 – 39,000 lb/hr (~8,000 scfm) in the front duct, rear OFA header press was 9.8 inwc.
- 22 – 23,000 lb/hr (~5,000 scfm) in the rear duct, front OFA header press was 11.7 inwc.

**The calculation is based on the input data of Reworld
Reworld is responsible for the quality of the input data**

3. Combustion Calculation

Waste Properties

		April 2024	August 2024
Fuel throughput	lbs/hr	12622	12602
High Heating value	Btu/lb	5659	5575
Water	% by wt.	20.69	20.90
Non-combustible matter	% by wt.	26.67	27.13
Carbon	% by wt.	29.579	29.188
Hydrogen	% by wt.	4.054	3.987
Oxygen	% by wt.	17.685	17.491
Nitrogen	% by wt.	0.621	0.614
Chlorine	% by wt.	0.550	0.542
Sulphur	% by wt.	0.141	0.139
Fluorine	% by wt.	0.009	0.009

- Heating value and throughput by input of Covanta Data
- Fuel composition determined by correction curves of Martin

3. Combustion Calculation

Calculation of combustion air

		April 2024	August 2024
Input			
Fuel throughput	lbs/hr	12,622	12,602
High Heating value	Btu/lb	5,659	5,575
Oxygen at boiler end	%, dry	10	10
Total air as input	lbs/hr	157,927	157,898
Air necessary to achieve oxygen	lbs/hr	210,692	207,227
Output			
Leakage air	lbs/hr	52,765	49,329
Oxygen at furnace	%, dry	6.264	6.508

- Total air flow by PLS value
- Oxygen of 10 % as assumed long time median (average is to influenced by disturbances in operation)

4. Combustion Calculation

Calculation of combustion air

		April 2024	August 2024
		Input	
Fuel throughput	lbs/hr	12,622	12,602
High Heating value	Btu/lb	5,659	5,575
Underfired Air	lbs/hr	96,926	96,897
Overfired Air	lbs/hr	61,001	61,000
Flue gas in furnace	lbs/hr	183,798	183,741
Oxygen in furnace	%	6.264	6.508
Flue gas at boiler end	lbs/hr	236,563	233,070
Oxygen at boiler end	%	10	10

4. Combustion Calculation

Validation with a boiler balance

	Mass Flow [lbs/hr]	Enthalpy [BUT/lb]	Enthalpy flow [kBUT/hr]
Input			
Fuel	27,827	4,995	138,990
Underfired Air	96,926	4	421
Overfired Air	61,001	1	53
Leakage Air	52,765	0	0
Feed Water	94,644	186	17,560
Sum			157,025
Output			
Flue gas	232,502	110	25,548
Life steam	93,917	1,339	125,763
Blow- down	728	490	357
Heat loss in the grate	-	-	2,086
Radiation loss	-	-	921
Sum	-	-	154,674

4. Combustion Calculation

Validation with a boiler balance

Additional information and assumptions:

- Reference temperature for enthalpies is 77 °F (25°C)
- Heating value of waste is the lower heating value
- The blow down rate of 0,75 %
- Flue gas outlet temperature is 18 °F higher than SDA Inlet temperature
- Feed water flow is the sum of steam flow and blowdown

Conclusion:

- Difference between input and output is 2351 kBTU/hr (2 % error)
- Data quality is acceptable

5. Thermal calculation

Calculation adiabatic combustion temperature

Adiabatic combustion temperature in the furnace:

$$\begin{aligned} h_{ad} &= (\dot{Q}_{Waste} - \dot{Q}_{Combustion\ loss} + \dot{Q}_{Underfired\ air} + \dot{Q}_{Overfired\ air}) / \dot{m}_{Flue\ gas, Furnace} \\ &= (\dot{m}_{Waste} h_{u, Waste} (1 - \epsilon_{loss}) + \dot{m}_{Underfired\ air} h_{Underfired\ air} + \dot{m}_{Overfired\ air} h_{Overfired\ air}) / \dot{m}_{Flue\ gas, Furnace} \\ h_{ad} &= f(T_{ad}) = h_{fluegas}(y = 0) = f(T_{ad}) \end{aligned}$$

- Water / steam data according to IAPWS R7-97(2012) [1]
- Flue gas data according to FDBR [2]

5. Thermal calculation

Simplified calculation of the temperature profile

The following approach is described in literature : “Wärmetechnische Berechnung der Wasserrohrkessel” [3]

Assumptions:

- Main heat transfer in the furnace as function of the height is radiation
- Ideal plug flow
- Idealized wall temperature

$$\dot{Q}_{\text{Transfer}}(y) = C_{1,2} A(y) (T_{\text{Flue gas}}^4(y) - T_{\text{Wall}}^4)$$

$$\dot{H}_{\text{Flue gas}}(y) = \dot{H}_{\text{Flue gas}}(y = 0) - \dot{Q}_{\text{Transfer}}(y)$$

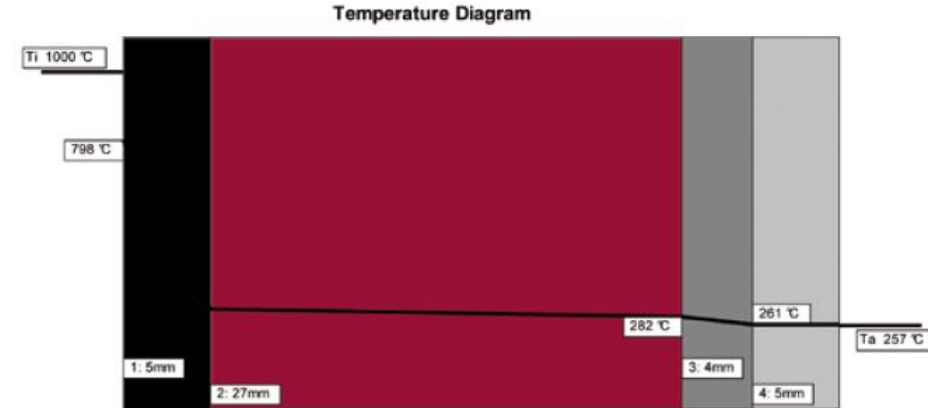
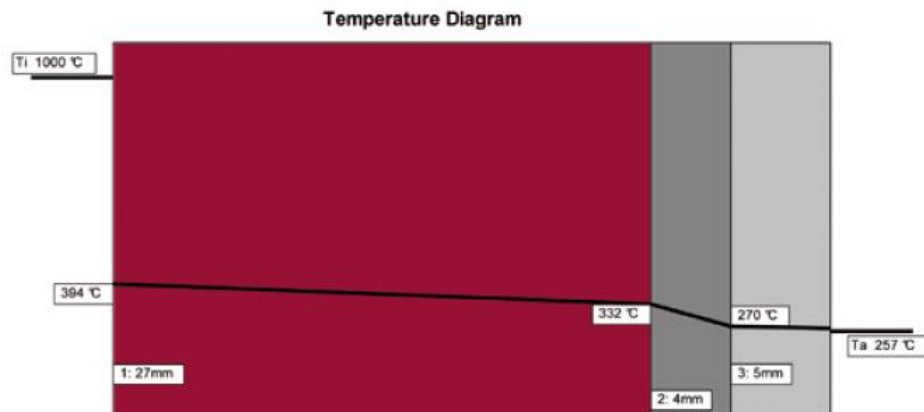
$$v_{\text{Flue gas}}(y) = \frac{\dot{m}_{\text{Flue gas}}}{A_{\text{cross section}} \rho (\dot{T}_{\text{Flue gas}}(y))}$$

5. Thermal calculation

Influence of fouling on the wall temperature (example calculation [4])

Wall Construction		Cond. Factor	Thickn.	Cond.	Temperature of Layers	
Material			mm	W/(mK)	Face °C	Mean °C
1: +SI107C	SiC brick		27	26,300	394,0	362,9
2: +MK100P	refractory mastic		4	3,951	331,8	301,1
3: +ST0425	steel		5	41,332	270,4	266,7
			36		263,1	

Wall Construction		Cond. Factor	Thickn.	Cond.	Temperature of Layers	
Material			mm	W/(mK)	Face °C	Mean °C
1: +MK597A	contamination		5	0,204	797,5	555,6
2: +SI107C	SiC brick		27	26,300	302,8	292,4
3: +MK100P	refractory mastic		4	3,936	282,0	271,8
4: +ST0425	steel		5	41,494	261,5	260,2
			41		259,0	



- The fouling is the main heat resistance and significantly determines the wall temperature
- Boiler walls are fouled very fast
- Influence of type of refractory is low in comparison to the fouling

5. Thermal calculation

Influence of fouling on the wall temperature (example measurements [5])

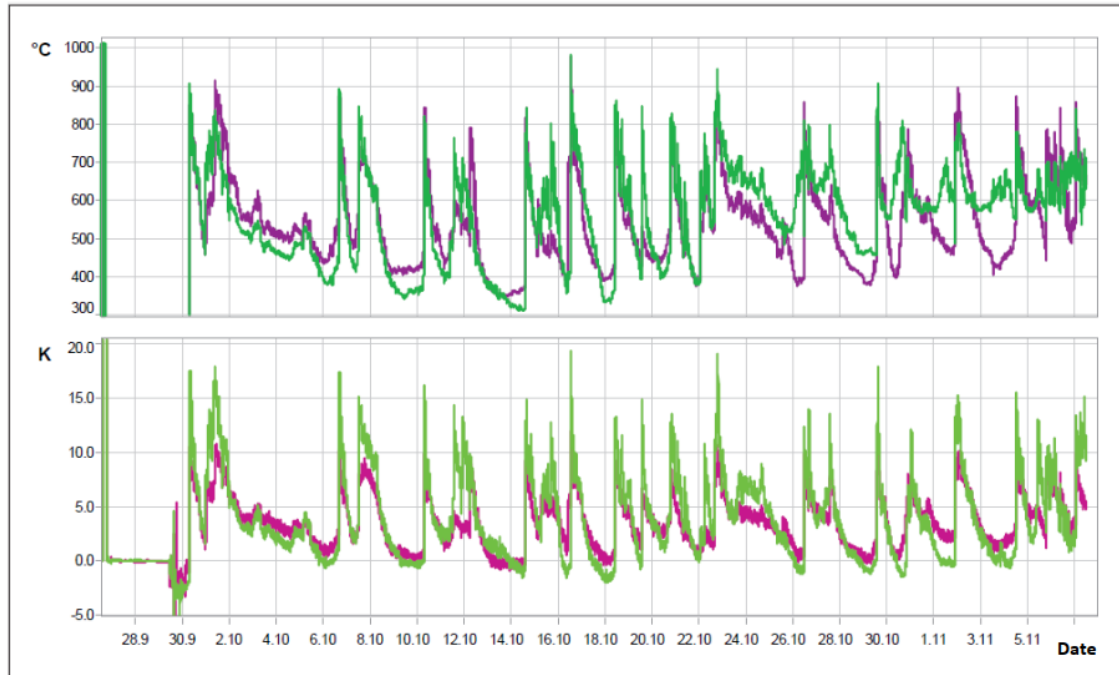
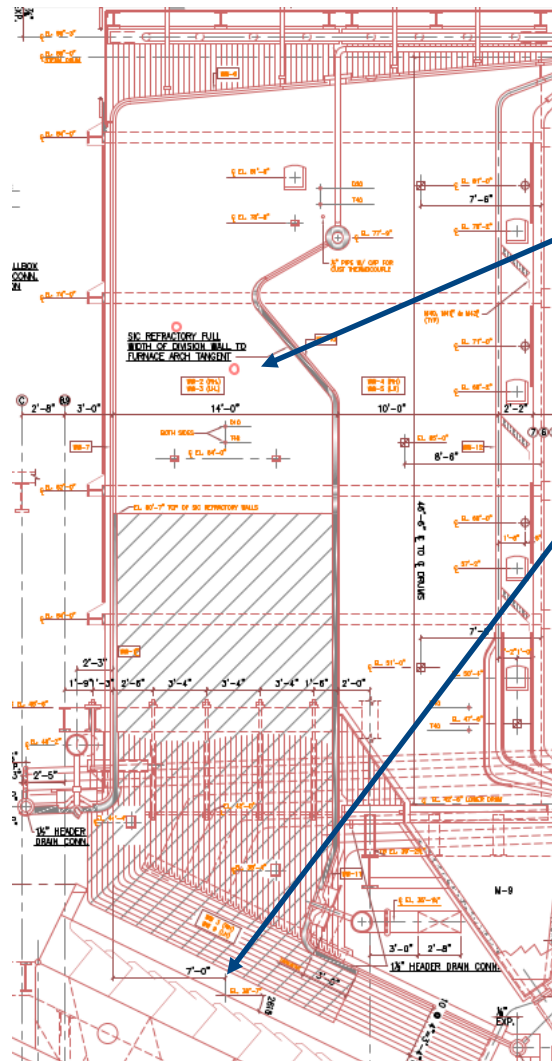


figure 7: curves for temperature (top) and temperature difference measurements (bottom) in rear-ventilated (green) and back-filled (purple) tile areas over time, measuring position 1 on left side wall; severely fluctuating and very high thermal load on refractory lining in this area is clearly recognisable

- The fouling is the main heat resistance and determines the wall temperature
- Boiler walls are fouled very fast
- Influence of type of refractory is low

5. Thermal calculation

Model fit to experimental data



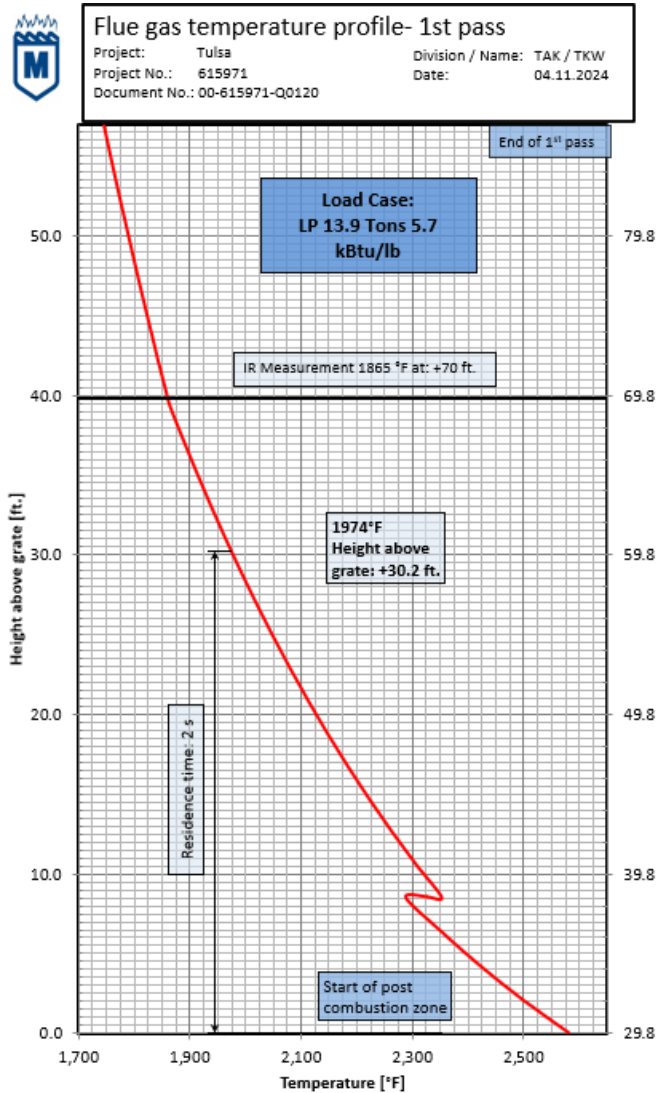
IR-Measurement

Adiabatic combustion temperature

- T_{Wall} is varied until the temperature profile matches the IR measurement at an elevation of 70 ft.
- $\dot{Q}_{Transfer}(y) \sim (T_{Flue\ gas}^4(y) - T_{Wall}^4)$ determines the characteristic of the curve
- $T_{Flue\ gas}(y)$ is calculated for several small increments
- $v_{Flue\ gas}(y)$ is calculated for several small increments

6. Results

Results for April 2024



- The residence time of two seconds ends 30.2 ft. above the grate
- At this height, the temperature is 1974 °F
- At a temperature of 2000 °F, the residence time is 1,9 s
- At a temperature of 1975 °F, the residence time is 2,0 s
- At a temperature of 1800 °F, the residence time is 3,4 s
- Temperature at grate level is 2584 °F

6. Results

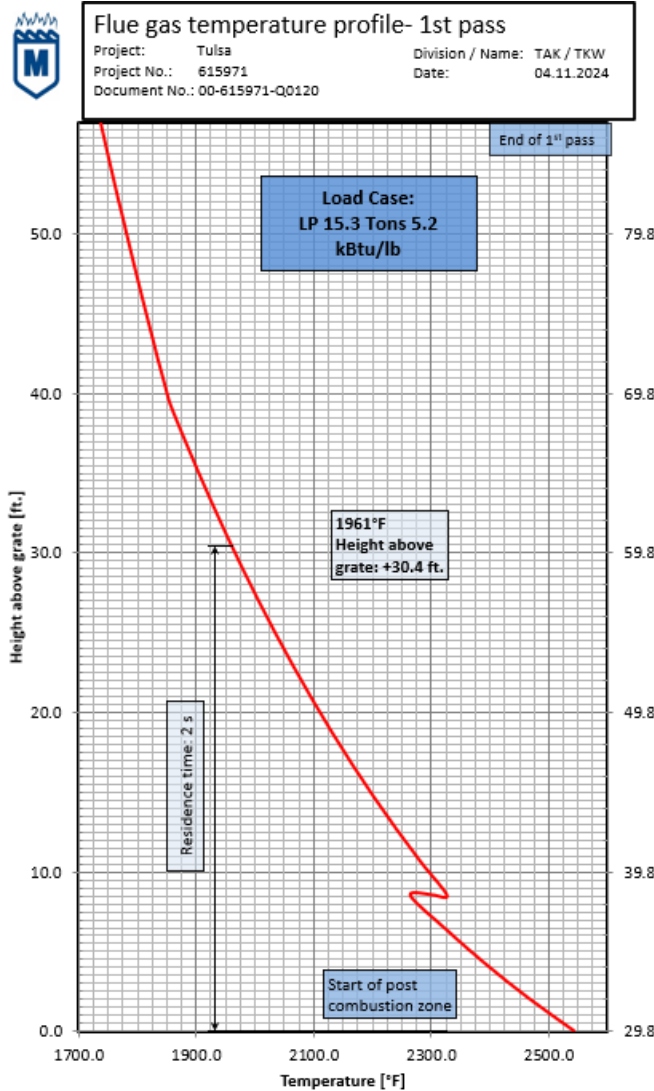
Additional load points

- Model A: Base is April 2024: 13.9 Tons, 5.7 kBtu/lb, 97 % thermal load
- Model B: 10 % more waste, heating value is reduced by 10 %: 15.3 Tons, 5.2 kBtu/lb, 97 % thermal load
- Model C: 10 % less waste, heating value is increased by 10 %: 12.5 Tons, 6.2 kBtu/lb, 97 % thermal load
- Model D: 10 % less waste than B, same heating value as B: 13.8 Tons, 5.2 kBtu/lb, 87 % thermal load
- Model E: 10 % less waste than C, same heating value as C: 11.3 Tons, 6.2 kBtu/lb, 87 % thermal load

The total combustion air is equal for 100 % load, the combustion air is reduced by 10 % for 87 % thermal loads

6. Results

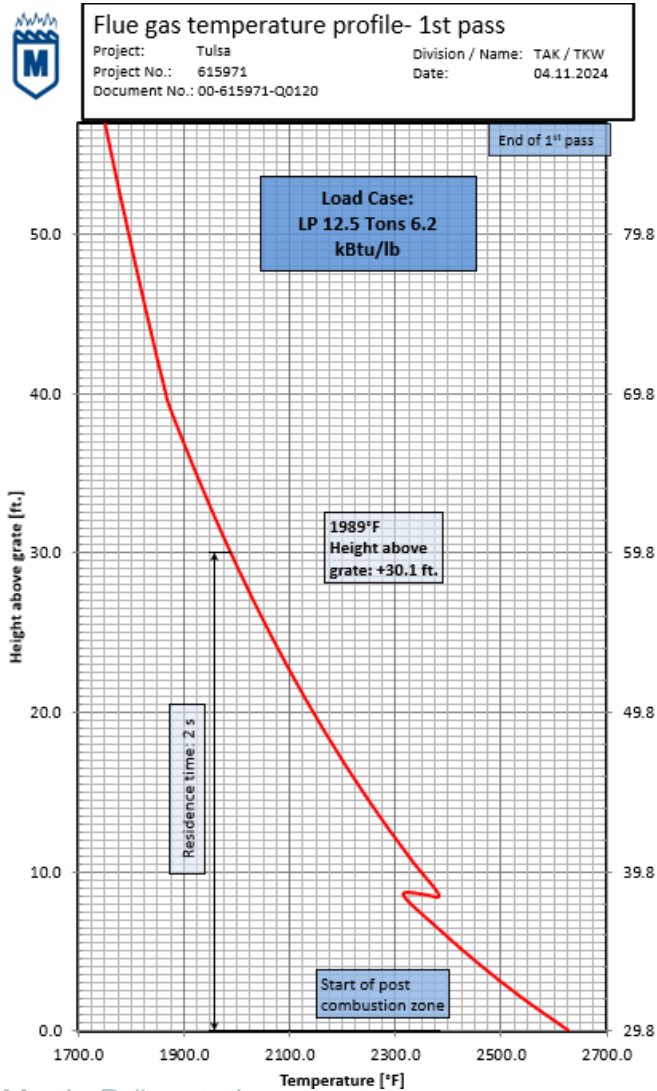
Results for Model B



- The residence time of two seconds ends 30.4 ft. over the grate
- At this height, the temperature is 1961 °F
- At a temperature of 2000 °F, the residence time is 1.8 s
- At a temperature of 1975 °F, the residence time is 1.9 s
- At a temperature of 1800 °F, the residence time is 3.3 s
- Temperature at grate level is 2544 °F

6. Results

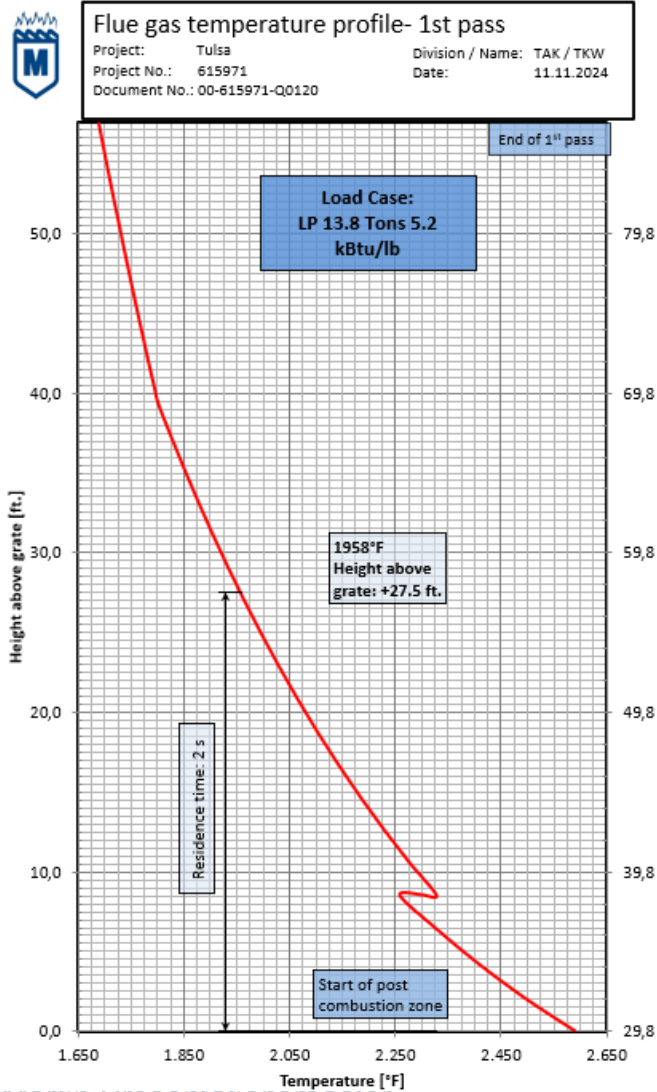
Results for Model C



- The residence time of two seconds ends 30.1 ft. over the grate
- At this height, the temperature is 1989 °F
- At a temperature of 2000 °F, the residence time is 1.9 s
- At a temperature of 1975 °F, the residence time is 2.1 s
- At a temperature of 1800 °F, the residence time is 3.5 s
- Temperature at grate level is 2630 °F

6. Results

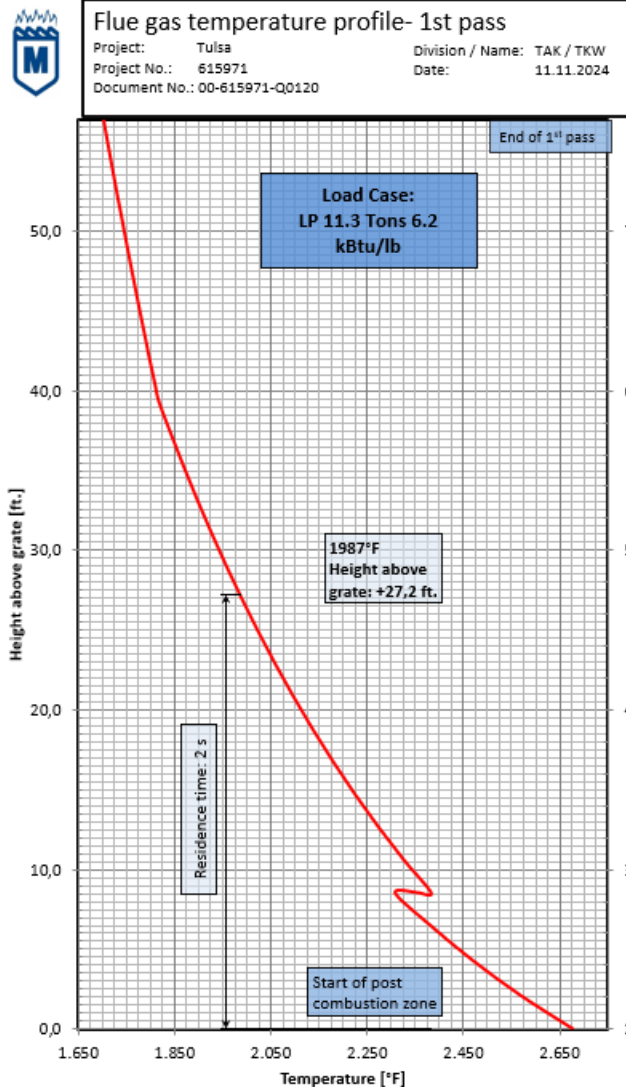
Results for Model D



- The residence time of two seconds ends 27.5 ft. over the grate
- At this height, the temperature is 1958 °F
- At a temperature of 2000 °F, the residence time is 1,8 s
- At a temperature of 1975 °F, the residence time is 1,9 s
- At a temperature of 1800 °F, the residence time is 3,0 s
- Temperature at grate level is 2,594 °F

6. Results

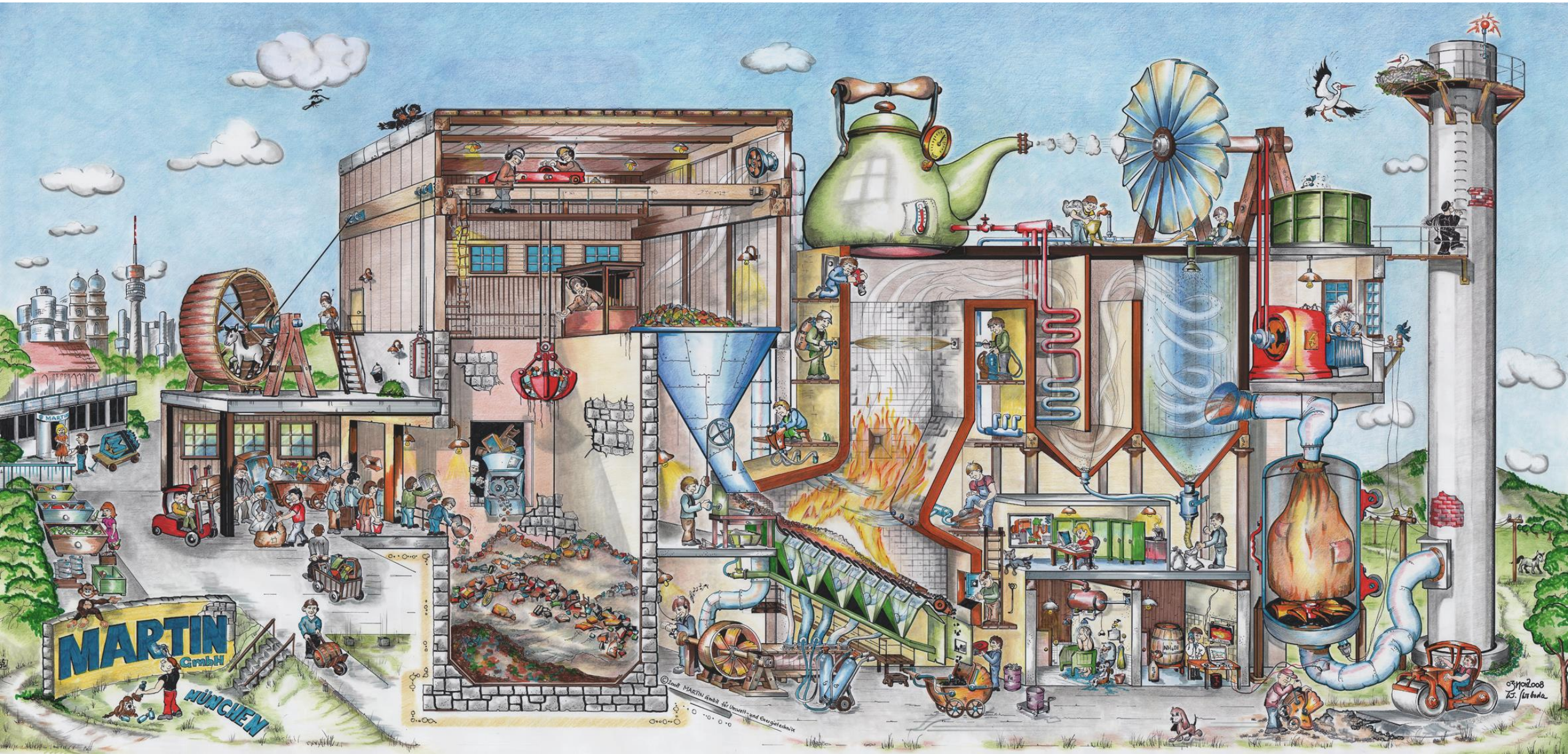
Results for Model E



- The residence time of two seconds ends 27.2 ft. over the grate
- At this height, the temperature is 1987 °F
- At a temperature of 2000 °F, the residence time is 1,9 s
- At a temperature of 1975 °F, the residence time is 2,1 s
- At a temperature of 1800 °F, the residence time is 3,2 s
- Temperature at grate level is 2,680 °F

7. Source of Literature

- [1] Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam, IAPWS R7-97(2012)
- [2] FDBR-Handbuch, Wärme-und Strömungstechnik, 2013
- [3] Wärmetechnische Berechnung der Wasserrohrkessel, Wasserrohrkesselverband Düsseldorf, 1963
- [4] Refractory linings for Waste Combines Heat & Power plants and Bio Mass Boilers with adhesive Tile system, Jünger+Gräter GmbH, Issue Nov 30, 2010
- [5] Temperature sensor technology: adjusting refractory lining to the requirements, Joos Brell, Dominik Molitor, Gabriele Magel, Sabine Hohmuth,2019



Appendix B

APPLICATION TO MODIFY A SOLID WASTE DISPOSAL FACILITY PERMIT

Date: November 12, 2023
Revised November 20, 2024

County: Tulsa

Send to:

Solid Waste Permitting Unit
Land Protection Division
Dept. of Environmental Quality
707 N. Robinson (PO Box 1677)
Oklahoma City, OK
73101-1677

FOR DEQ USE	
DEQ Log No.	_____
No. Copies	_____
Date Received:	_____

Covanta Tulsa Renewable Energy LLC proposes to modify the permit of

(Applicant's Name)
the Covanta Tulsa Facility, located at 2122 S. Yukon Ave, Tulsa, OK 74107
(Facility Name) *(Exact legal description:*
more specifically described in the attached legal description
metes & bounds, platted lot, or land survey. Append extra sheets if necessary)

in Tulsa County, Oklahoma. We hereby make application for a modification of existing permit number 3572033 as required by the **Oklahoma Solid Waste Management Act** and the Rules pursuant thereto.

Remarks & brief description of proposed modification:

This permit modification will allow the facility to combust up to 40,000 tons per year of regulated medical waste as identified in the permit application. An automated delivery system and segregated parking area are additionally planned in order to ensure safe storage, operation, and effective pathogen destruction.

Applicant or Authorized Agent:
James Luckey
Signature
James Luckey, Facility Manager
Typed Name

Address: 2122 S. Yukon Ave
City: Tulsa State: OK

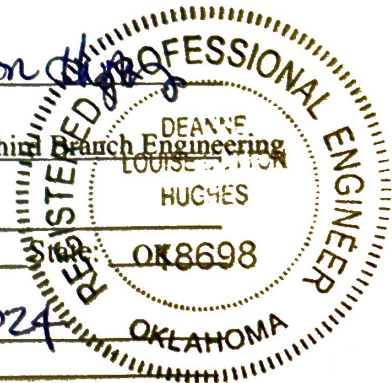
Date signed: 11/20/2024
Phone: 918.699.0011

Facility Address (if any): _____
2122 S. Yukon Ave, Tulsa, OK 74107

Preparing Engineer:
Deanne Louise Dutton Hughes
Signature
Deanne Louise Dutton Hughes, Third Branch Engineering
Typed Name

Address: 2789 E 45th Pl
City: Tulsa

Date signed: 11/20/2024
Phone: 405.202.9605



DEQ USE ONLY

VERIFICATION¹

STATE OF OKLAHOMA)
)
COUNTY OF _____) ss

James L. Luckey III, of lawful age, being first duly sworn, upon oath state that I have read the foregoing APPLICATION TO MODIFY A SOLID WASTE DISPOSAL FACILITY PERMIT, that I am familiar with the matters set forth therein, and that the same are true to the best of my information and belief.

James L. Luckey III
Applicant

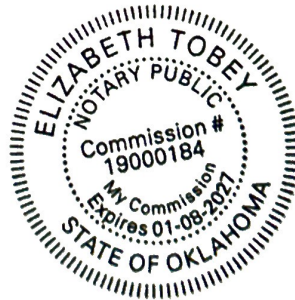
Subscribed and sworn to before me this 20th day of November, 2024

by James L. Luckey III (Applicant or legal representative).

Elizabeth Tobey
Notary Public

My commission expires:

01-08-24



¹ This Verification is required for a Tier III modification application.

Legal Description:

Northerly nine hundred feet (900') of the easterly one thousand eighty five feet (1085') of NW
1/4 of the NE 1/4 of Section 15 Township 19 North Range 12 East Tulsa County, Oklahoma