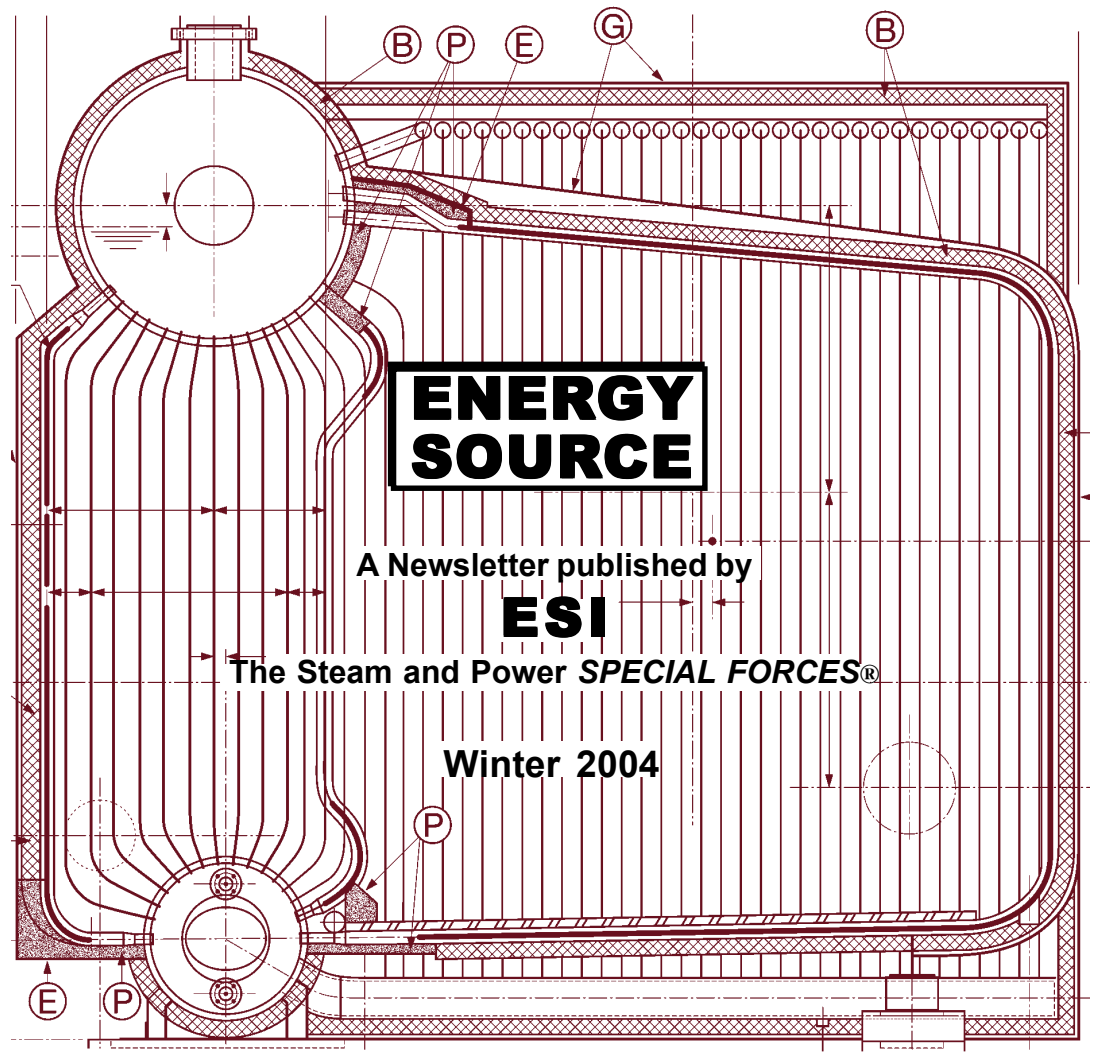


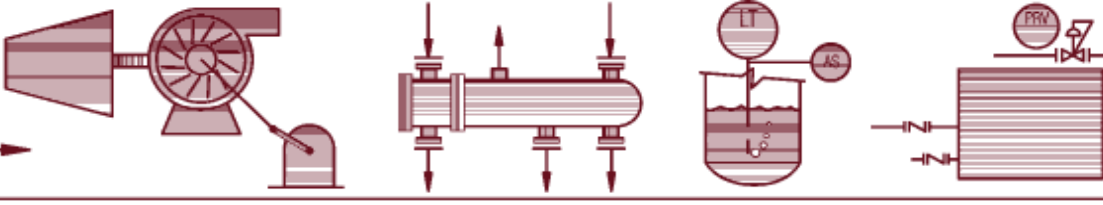
ENERGY SOURCE

A Newsletter published by

ESI

The Steam and Power *SPECIAL FORCES*®

Winter 2004



THE BUYER'S GUIDE TO PACKAGE BOILER DESIGN

By: William L. Reeves, P.E., President, ESI

Editor's Note: "The Buyer's Guide To Package Boiler Design" continues with a discussion regarding the current state of burner technology and typical emissions when firing natural gas and fuel oil. This series of articles is focused on the critical items one should consider when purchasing a new package boiler. Please see our Spring, Summer, and Fall 2003 Issues of the ENERGY SOURCE for the previous articles in this series.

Besides the boiler itself, the burner is the most important piece of equipment in the package boiler design. You may recall that a previous article in this series (*Summer 2003 Issue*) discussed the importance of furnace design on burner emissions. As a matter of review, the necessity to produce lower NO_x emissions has made the boiler furnace volume and geometry increasingly more important in the overall boiler design. A conservative larger furnace volume translates into a lower volumetric furnace heat release rate, which reduces the heat gradient through the furnace tube walls and the furnace temperatures. The furnace geometry is important because the furnace must have the adequate height, width, and length so that the burner combustion can be staged without flame impingement on the furnace tube walls.

Over the past 15 years, the major burner manufacturers have made phenomenal strides in developing new burners that meet more stringent environmental regulations. Due to increasingly restrictive regulations, reducing nitrous oxide (NO_x) emissions has been the primary focus. NO_x emissions lead to ozone and photochemical smog problems in higher concentrations; therefore, in some major metropolitan areas, specifically areas that are non-attainment areas for NO_x and ozone, the required NO_x emissions levels have pushed the limits of burner technology.

NO_x is formed by the combination of nitrogen and oxygen molecules. The nitrogen portion of NO_x comes from two sources: nitrogen in the air and nitrogen contained in the fuel. NO_x formed from fuel-bound nitrogen, especially in liquid fuels, is extremely difficult, if not impossible to control. Therefore, current burner technology has focused on minimizing the formation of NO_x generated from nitrogen in the combustion air combining with oxygen molecules during the combustion process. One of the key components in the formation of NO_x is temperature. NO_x formation is minimized below a temperature of 1500°F. Another key component is that both oxygen and nitrogen molecules must be sufficiently abundant to find each other or the reaction will not take place. Current burner designs control these two factors by extending the combustion process so that complete combustion of the fuel occurs much further from the initial combustion zone. This is a much different concept than 15 to 20 years ago when good combustion was defined as the hottest flame possible to quickly burn all of the fuel.

Burner manufacturers have developed many "tactics" to extend the combustion process. These include

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ENERGY SOURCE

The *ENERGY SOURCE* is published quarterly for customers, employees, and friends of ESI Inc. of Tennessee.

ESI is the Steam and Power *SPECIAL FORCES*® providing clients with innovative, cost-effective, and environmentally-friendly solutions.

If you have any suggestions or comments about the newsletter feel free to call us at 770-427-6200 or e-mail us at energysource@esitenn.com.

Deanna White
Managing Editor

ESI Selected for New Coal-Fired Circulating Fluid Bed Boiler

By: Deanna White, Marketing Manager, ESI

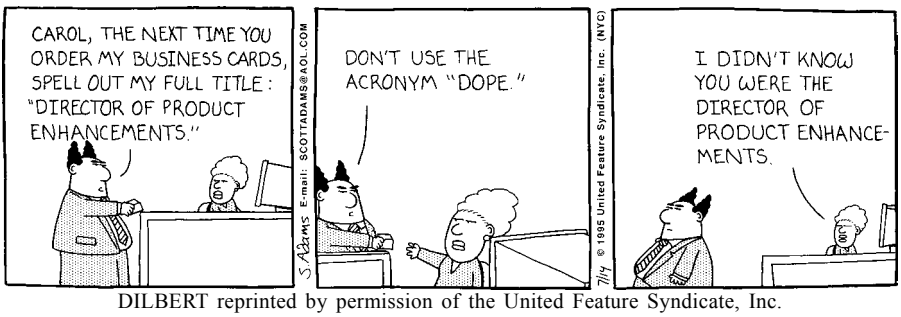
ESI is excited to announce that we have been selected by Corn Products International, Inc. to provide engineering, construction management, project management, start-up, and operator training for a new coal-fired circulating fluid bed boiler system located at their Argo Plant in Bedford Park, Illinois. This new system will replace three existing coal-fired boilers, which will reduce the plant's emissions as well as provide more efficient and effective energy production.

This project will include a 1,100,000 pph coal-fired circulating fluid bed boiler, air pollution control system, coal handling system, limestone handling system, ash handling system, and distributed control system all housed in a new building with a central plant control room. ESI will perform the tie-ins to the existing plant and upgrade the controls of an existing 300,000 pph natural gas-fired boiler to the new DCS.

Engineering for this project is currently underway and construction is scheduled for completion in December 2005. For additional information, please visit us on-line (ESI @ www.esitenn.com and Corn Products @ www.cornproducts.com) or call Jeff White with ESI at 770-427-6200. We look forward to hearing from you!

"We look forward to working with Corn Products on this important project. This is the type of project where ESI can really apply our expertise in the design and construction of a coal-fired power plant while utilizing our business model to save Corn Products millions of dollars."
Bill Reeves
President, ESI

"This long-term energy solution gives us the opportunity to substantially reduce the plant's emissions while enhancing its efficiency and, therefore, competitiveness for years to come. The project will also benefit our employees and the economic well being of the surrounding community as well as the state, as we intend to use Illinois coal. As one of the founding members of our community, we are committed to being a supportive neighbor to an area that is a good place to live and work."
Jack Fortnum
Vice President of Corn Products International and President US Business



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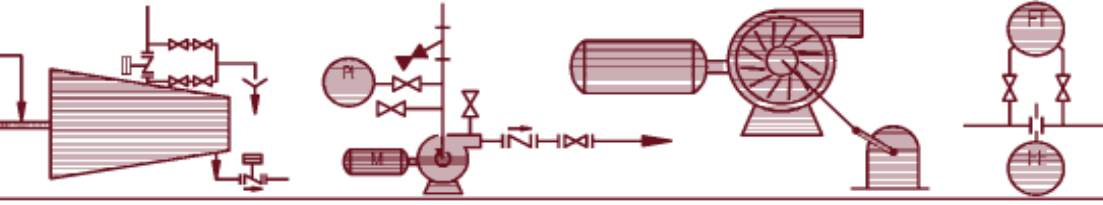

The Special Theory of Santa-tivity (or Do Reindeer Understand Physics?)

By: Patrick M. Hayes, P.E.,
Project Systems Engineer, ESI

Editor's Note: As the Editor of the "ENERGY SOURCE" Newsletter, ESI has always been dedicated to write articles that assist those that work in the production of steam and power; however, we have departed on this article. We do hope you find it interesting or at least amusing. Happy Holidays from ESI!

How would you respond if a child asked you "If Einstein predicted that nothing could travel faster than the speed of light, then how does Santa make it to every house in the world in one night?" There are several leading theories that might describe Santa's fantastic voyage, so let's touch on the most prominent and perhaps you can decide which theory you believe.

The Short Course on Theoretical Physics

Most people agree that by standard Newtonian Physics, the proposition of one jolly old elf delivering all those toys is impossible. Thankfully as we gain more understanding of how things work, we are given more and more options to consider that explain this amazing phenomenon.

We got here when Newtonian Physics gave way to Einstein's theories of Special and General Relativity, which dwell on gravity and time-space. At roughly the same time, theories were developing for electricity and magnetism, which were discovered to be intrinsically linked. Thus was born the school of "Electro-Magnetism". Quantum theory rose to prominence in the 1920's and 1930's when we learned to split the atom and that the foundation of matter is smaller than we could have imagined. Research of this micro world led to the development of the strong and weak nuclear theories to describe the interactions of the sub-atomic realm. So now, modern physics theory is centered on the four fundamental forces of nature: gravity, strong nuclear, weak nuclear, and electromagnetic forces.

No one has adequately explained how any of these competing forces of nature fit together. The hottest realm of theoretical physics today is in "unification" by which someone is going to become very famous by figuring out – why doesn't gravity work on small scales and why doesn't quantum mechanics work on macro scales? And speaking of "time", none of our theories explain time – what is time, what generates time, is time unidirectional, and am I already late for something?

Back to Santa Claus

I will not attempt to explain loop-theory, string-theory, or M-theory (suffice it to say that the experts are still arguing these theories with each other) – however, each of these theories leaves the door open for side-effects such as quantum teleportation, worm holes, and my favorite…time travel. All three of these phenomena would allow a right jolly old elf to deliver toys in one night without abusing his reindeer and incurring the wrath of PETA.

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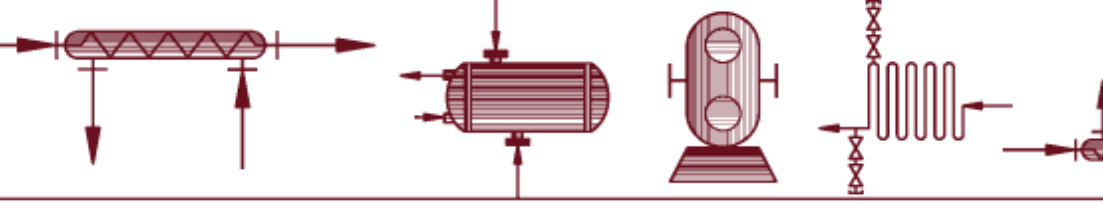

THE BUYER'S GUIDE... *Continued from Page 1*

each of the following in various combinations:

- Staging of combustion air so that a portion of the air needed for combustion is introduced later in the combustion process.
- Staging of the fuel so that the fuel is introduced in separate areas within the burner to allow better control of the combustion process.
- Introduction of flue gas recirculation, either through a separate fan or via the combustion air fan, to reduce the concentration of oxygen introduced into the burner and therefore extend combustion.

One needs to realize that each of the methodologies to reduce NO_x emissions is accomplishing the task by slowing the combustion process and cooling the flame. Doing so requires operations personnel to have tighter and tighter control over the combustion process to insure the boiler is maintained in a safe fuel/air zone. In addition, reduced flame temperature and staged air combustion tend to increase carbon monoxide (CO) emissions and volatile organic compound (VOC) emissions. Therefore, it has been quite a task for the burner manufacturers to improve designs to reduce NO_x emissions while maintaining safety and reasonable CO and VOC emissions levels.

Current burner technology essentially consists of three basic levels of NO_x emissions control. All of the following strategies utilize multiple air zones and air staging with varying levels of flue gas recirculation.

- State-of-the-art conventional technology with no flue gas recirculation
- Low NO_x technology with limited flue gas recirculation
- Ultra low NO_x technology with maximum safe flue gas recirculation

Representative current emissions levels firing natural gas and #2 fuel oil in a well-designed package boiler are presented in the table below.

Emissions	Conventional		Low NOx		Ultra Low NOx	
	Natural Gas	#2 Fuel Oil	Natural Gas	#2 Fuel Oil	Natural Gas	#2 Fuel Oil
NOx	75	130	30	75	9	65
CO	100	100	100	100	25	100
VOC	10	10	10	10	3	10

Note: Numbers are in parts per million by volume with CO_2 corrected to 3%.

The operation of a well-designed burner system using a current state-of-the-art conventional or low NO_x burner with zero to about 15% flue gas recirculation is very stable and highly reliable. The commercially available ultra low NO_x burner technologies operate at or very near the maximum level of flue gas recirculation that can safely be utilized. If the burner and combustion control system is not maintained extremely well and the operation monitored very closely, the burner could suffer from excessive vibration, rumbling, flame instability, and even a possible minor explosion. The first generation of ultra low NO_x burners experienced all these problems; however, the most recent ultra low NO_x burner technologies have been refined by the manufacturers to become safer and more reliable.

Whenever a burner is purchased, depending on the application and emissions levels required, ESI recommends the following features be included to improve reliability, maintenance, and operations:

- Fuel train assemblies fully welded to the maximum extent possible - This feature greatly reduces housekeeping problems and safety hazards associated with minor nuisance leaks.
- Dual flame scanners - This feature eliminates burner/boiler-forced outages due to flame scanner failure.

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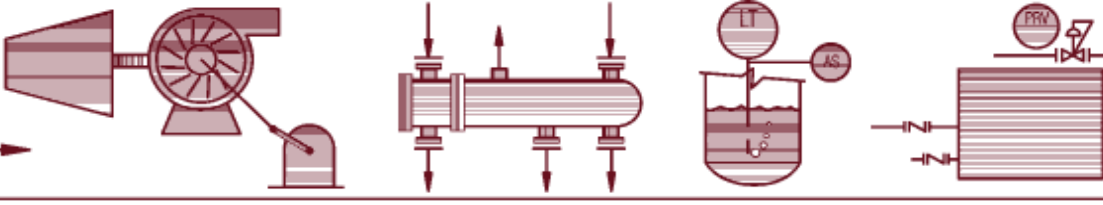

The Special Theory of Santa-tivity... *Continued from Page 3*

The Multiverse (multiple universes) is another competing theory, which could explain the physics of Santa. This theory springs from the uncertainty arising in quantum equations and in real life experiments in which multiple outcomes are observed (the most famous anomaly involves aiming a laser at a slit the width of a photon with results that show twice the number of incoming photons hitting the target wall, which is currently unexplained). Basically the premise is that for every possible outcome to every possible situation there is a universe, which exists in which that outcome is observed. Proponents of this theory claim that there is a thin divide which separates each reality and that when we examine things on a micro scale, such as electrons circling the nucleus of an atom, the outcome of the observation is "blurred" by bleed from the neighboring multiverses. In this theory, there are an infinite number of Santas who might be able to travel the bleed between multiverses and accomplish the job in all places and at all times. This would explain why you do not always get the toy you want, because the gift you receive might not be for you – it might be for your counterpart in another multiverse.

Lastly is the theory of the Divine. God created the universe in a thought and since Saint Nicholas is one of his Divine Appointees, who am I to say that he cannot bring Joy (and Star Wars® action figures) to every boy and girl in the length of one Holy Night.

The End (or the beginning)

Now, if we can just figure out how to get Santa to stop leaving lumps of coal for everyone who has been naughty and instead deliver that coal to the local utility – maybe we can cut your operating costs and improve your return on investment. I hope you have gotten a laugh from my musings on the Holiday Season. We here at ESI hope you had a Happy Holiday!

THE BUYER'S GUIDE... *Continued from Page 4*

- Self-checking flame scanners - This will detect scanner problems early.
- Selection of all fuel train components for the maximum operating pressure and temperatures possible - This will eliminate potential problems associated with upset conditions.
- Careful selection and layout of the fuel, air, and flue gas monitoring equipment – This will insure accurate and repeatable control signals.
- Oxygen analyzers on the burner windbox and boiler flue gas exit with alarms and burner trips if the respective oxygen levels fall below safe zones – This should help detect dangerous fuel-rich mixture situations and shut the burner down.
- Careful selection and design of the fuel, air, and flue gas control devices – This will insure that even in upset conditions, combustion is always maintained in a stable zone.
- Design of the burner safeguard and combustion control systems by personnel experienced in the proper design of these systems who are familiar with the latest NFPA and insurance requirements – This will result in a safe and insurable facility.

Look for the Spring 2004 issue of the *ENERGY SOURCE* for the last article in this series, where we will discuss some of the critical parameters in the design of an economizer, fan, burner management system, boiler trim, and other boiler auxiliary equipment.