1) Q: Are there any additional considerations for Lo NOx rated boilers?
   
   A: When sizing chimney diameter, one must consider that FGR may cause a different draft range (inches of W.C.) because FGR can add to the mass flow. A higher mass flow may cause that a larger chimney diameter be selected. For low NOx applications, we recommend verifying with the boiler Mfr. for the expected mass flow before requesting a chimney sizing.

2) Q: Would it be good to place a pressure gauge upstream from the stack liner as a safety to tell if there is any blockage?

   A: It can be useful but it's not commonly done as they can be difficult to get to inside the chimney. Test ports are provided and can be used to verify draft pressures from time to time. If draft is too high, draft control with damper(s) can be installed. If draft is too low and the chimney cannot be modified, raising the exhaust temperature can help improve draft. Please note: standard issued test ports are situated at the boiler outlet on the starting adapter.

3) Q: What is the recommended pitch of the horizontal section of breeching?

   A: For condensing applications and any section of a stack that may get condensation: 1/4” per foot is the recommended pitch sloping down towards the boiler(s), or drain sections, for condensate return. For non-condensing application: Horizontal breeching is fine and in some cases it is rather suggested to slope down towards the stack, where a drain is located, to make absolutely sure that no condensate, if it occurred, would return to a boiler not designed to receive condensate.

4) Q: Is that pitch direction down towards the boiler?

   A: For condensing applications: down towards the boiler(s), or drain sections, for condensate return.
   
   For non-condensing application: Horizontal breeching is fine and in some cases it is rather suggested to slope down towards the stack, where a drain is located, to make absolutely sure that no condensate, if it occurred, would return to a boiler not designed to receive condensate.

5) Q: With reference to your slide showing 1st scenario, why do we need to reach 31st floor for the stack to discharge the flue gas? What is the basis/code in designing the stack?

   A: For that project, we offered an option for a 70 foot freestanding stack located downwind 200 feet away from the building. That was not accepted as the building is historical and must keep an original appearance.
Regarding code: You can read the following in the NFPA54 (2006) code:

<<12.9.4 Through-the-wall vents for Category II and Category IV appliances and non-categorized condensing appliances shall not terminate over public walkways or over an area where condensate or vapor could create a nuisance or hazard or could be detrimental to the operation of regulators, relief valves, or other equipment. Where local experience indicates that condensate is a problem with Category I and Category III appliances, this provision shall also apply.>>

Based on this, we can say that in scenario #2, there was sufficient risk of getting condensate to be ejected out of the stack exit. If that had been exhausted from the side of the building at any height, it could have created nuisances by dripping on outside walls (making them dirty) or on windows (impairing the view and the appearance of the building).

With that stated, we must nevertheless recognize that many of the highest building structures of the world have some sort of venting through outside walls. In cases like that, local codes must be followed, engineers designing the system must make sure that no condensate will be present in the exhaust, maintain sufficient exit velocities (often with ID fans) and provide access for maintenance and cleaning at the exit point.

6) **Q:** In designing the stack, do we need to provide condensate line? Since the height of the stack reached 31st floor, the volume of condensation accumulates at the bottom of the stack at high velocity. How can you consider this factor in the design?

**A:** The best designs will have a tee and drain cap at the bottom to collect the condensate. You will then need to connect a drain line to neutralize effluent before entering the sewer discharge.

7) **Q:** We all know the stack is at high temperature, does the riser shaft need to be fire rated?

**A:** Regulations for fire rating of shafts depend on the building codes of the various states. Although UL103 certified chimneys do not require enclosures, chimneys are just one of many items in a shaft that can be considered an eventual fire hazard. We usually see electrical cables in these shafts, for example, that can be fire hazards. In New Jersey, for example, a building code states the following:

<<707.4 Fire-resistance rating: Shaft enclosures shall have a fire-resistance rating of not less than 2 hours where connecting four stories or more, and not less than 1 hour where connecting less than four stories. The number of stories connected by the shaft enclosure shall include any basement but not any mezzanines. Shaft enclosures shall have a fire-resistance rating not less than the floor assembly penetrated, but need not exceed 2 hours.>>

Since building codes can vary from one city to another, we recommend you verify what is required in your area.
8) Q: Are the dampers used in the breeching required to have special certification?
   A: No special certification, but need to be rated for the temperatures and pressures to which they will be exposed.

9) Q: How do you size the combined vents?
   A: This is a mass flow and temperature calculation, increasing the diameters of the breeching sections as more boilers are added to the system before entering the stack. Once the breeching diameters for each individual boilers (branches) are determined, the combined breeching for the connection of multiple branches need to have a cross-section area equal or superior to the total cross-section areas of the connected branches, if we want to prevent any draft losses. In some cases however, some draft losses may be unavoidable due to sizing, because of space limitations. In such cases, there are other ways to make-up for these losses and recover more draft in the sizing of other parts of the exhaust system.

10) Q: I saw a red paste in some of the pictures. Is this a sealant of some type?
    A: Yes. The following video shows how sealant is applied: https://vimeo.com/user9150739/review/53109891/98a12c2d00
    There are different sealants to be used, for the internal joints, depending on the application temperature rating, and also some sealants for external joints to resist to outdoors climate.

11) Q: How did you resolve the expansion on 435 feet stack?
    A: As you will be able to understand in more details, when you listen again to the recording that will be posted on C-B’s website, the thermal expansion was resolved by treating it 36 feet at a time, because at every third floor there was a fixed support holding the next 36 feet of stack above it, and just below that support there was a variable length section (an expansion joint) that collapses and extends during operation and shutdown. In these expansion joints, there are slip rings that contain the pressure and are made not to leak.

12) Q: On a multiple boiler operation. Is it common for 3-4 boilers to share the same stack?
    A: In many cases this is the most cost effective and as such, is the most common; however, separate stacks are also used when certain venting issues prohibit a reliable and safe operation from being accomplished with a single venting arrangement.
13) Q: I think Patrice touched on this, but does the type of fuel affect the size of the flue for dual fuel applications?

A: Yes. Mass flow is a little higher when oil is burned and the stack size must account for the largest flow that can be expected. Oil can also create more potential of corrosion so the choice of the inner material of the chimney will also be affected.

14) Q: Are the supports used in slide #36 guide supports or wall anchored supports with the adjustable length fittings combined with them?

A: In slide #36, what you see are two wall anchored (fixed) supports spaced 36 feet apart. These support the weight of the chimney. In between these two supports, you can see two more lines at equal distance. These are the positions of guides that let the chimney sections expand and retract. They are only there to keep the chimney straight.

15) Q: With a multiple boiler common vent setup with modulating draft control, where does the pressure reference go?

A: If only one damper and draft control is installed on the common breeching, then the process variable in this case is in the vertical stack. However, if like in scenarios #1 and #2 there are dampers on each boiler, then the reference points are in the branch of each boiler and is setup so each boiler’s damper closes and opens independently from other dampers to keep the boiler on which it is installed optimally operating for the draft range that it is designed for.

16) Q: What is the recommended flue gas velocity for stack sizing

A: Each chimney manufacturer has its own rules of thumb for this and customers often ask about noise levels in between floors and velocity at exit point for stack dispersion. How noise will resonate will also depend on chimney construction (single vs double wall, small vs large diameters) and how it is anchored and enclosed. Possible rules of thumb could be a minimum of 5 feet per second (fps) to prevent condensation deposits, a maximum of 30-35 fps in residential buildings, and no firm limit in industrial applications, although above 50 fps or so we must consider that lots of energy is getting wasted in pressure losses. This example was for boiler exhaust. Velocities can be different for other appliances like generators (often higher) and ovens (often lower).

17) Q: Formation of condensate in negative pressure is a result from the total height of stack?

A: This is a possible contributor, but it can occur in the breeching as well. That is why firing rate(s) of the connected boiler(s), and fuel type all need to be evaluated along with the type of insulating materials employed. Objective in a non-condensing boiler application is to keep below dew point as much as possible.
18) Q: In your opinion, how can we recover energy with these stack configurations?

A: Look at stack economizers mounted on the vent outlet of the boiler both non-condensing or condensing types. Condensing, if you have a consistent source of cold water which needs to be heated. This will cause the gasses to condense; capturing the latent energy which otherwise will be wasted. The non-condensing economizers capture the sensible energy, sending it to the boiler’s feed water supply.

19) Q: Can drain from stack go directly to a sanitary sewer?

A: It must be neutralized to prevent possible contaminants from entering the sewer water.

20) Q: What code dictates whether a stack terminates approximately 8 feet above building roof and the 150 foot tall brick stack?

A: The stack termination height above a roof is determined by the following two NFPA codes.

- NFPA211, Section 211-12, Chapter 4 General Requirements, subsection 4.2 Termination (Height).
- NFPA54, Chapter 12 Venting for Appliances. Section 12.6.2 Termination.

For termination above a brick stack, we use a standard of 3’ above top of masonry chimney. This covers most local codes.

21) Q: Who is responsible for proper design of exhaust system on boiler? Is it the stack manufacturer or stack expert/consultant and is it subject to government approval?

A: The responsibility lies with the stack manufacturer, PROVIDED he is given accurate information on the boiler’s operating characteristics (condensing or noncondensing), fuels being burned, rated capacity, turndown, operating pressures, physical in plant limitations, etc. As far as government approval, this varies depending on locale, but normally the government is not involved per se.

22) Q: Do you recommend auto drains or manual drains at the drain points?

A: No preference. However in positive static pressure applications, with a simple open drain line, there should be in one or more places of that line a point of higher elevation (like a siphon) to keep some condensate in place and prevent exhaust to come out as a gas.
23) Q: Do designs and draft calculations for Category III appliances typically have to be stamped by a P.E.?
   A: Not at Cleaver-Brooks, unless the representative asks for it. However, the local engineer specifying the project needs to approve that the draft calculation results and chimney sizes provided by C-B meet his expectations.

24) Q: Does outside wind affect draft condensate?
   A: Wind is a factor which needs to be considered as it may create back pressure and as such impede the normal draft condition. This is why adjacent buildings and other obstructions near the stack need to be evaluated for downdraft reasons. Wind velocity is also a reason stack caps are employed.

25) Q: How do you determine the size of the combined stack?
   A: Mathematical formulations based on mass flow and temperature at the maximum condition. Please look at the answer of question #9. It was the same question.

26) Q: Is recommended velocity based on gross or free area of the boiler room louvers?
   A: It is based on the total of the free area (without obstruction) of the openings. In the case of metal louvers, NFPA54, section 9.3.7.1 Louvers and Grilles states that metal louvers can be considered as having 75% of free open area.

27) Q: Any reliability issues with induced draft fans (as they operate in difficult conditions)?
   A: Yes, since your system is totally dependent on the fan. So if it breaks down your boiler cannot be used.

28) Q: Are flue sizing and application programs available?
   A: Stack manufacturers have their own software for this purpose, and it is proprietary for competitive and liability reasons. A software program in the hands of a person who is not trained and knowledgeable about proper vent sizing and design could be very dangerous.

29) Q: Is there a rule of thumb regarding allowable expansion?
   A: Breeching expands approx. 1” per 100 feet for every 100 deg. F increase in temperature over the ambient temperature surrounding its outer surface.

30) Q: Is it good practice to use a fan on the top of the vent to overcome any loss of draft?
   A: Induced draft fans are used in the applications where negative draft is nonexistent under certain conditions. In these cases, both horizontal (in breeching) and vertical (top of stack) fans may be employed. The horizontal fan has the
advantage of being indoors, and out of the elements when service is required. Both types; however, do the job, becoming a customer preference.

31) Q: How is low NOx controlled to maintain flue static with a bypass duct?
   A: NOx is controlled in the combustion process with low NOx burners and/or Flue Gas Re-circulation (FGR). In either or both cases, the stack designer knows what the temperatures and maximum mass flow will be, and designs the stack system accordingly. By-pass is really not the issue.

32) Q: Do you work on Galvanizing Kettles, Forging Furnaces and Other Combustion Equipment - as well as boilers?
   A: Yes, we work on various applications besides boilers, and would welcome your inquiry.

33) Q: When is it good practice to use barometric dampers? Can these be used in lieu of control dampers?
   A: There are certain applications which might allow the barometric as being the damper of choice, but in our experience, there are many factors which can impact proper draft, and the barometric damper does not accommodate all of them.

34) Q: Should stainless steel be used in all potential condensing situations. Is stainless inner and aluminum outer OK for possible condensing situation?
   A: Yes. Also, when the outer surface is made of aluminized steel, the customer is informed that this material is fine (and more economical) when used indoor, but not ideal when the chimney is exposed to the climate outdoor. Be aware that if the chimney is not assembled as per the provided instructions and it happens to leak condensate in between the chimney walls, then aluminized steel will corrode faster.

35) Q: How often is the wall thickness of the stack to be tested for corrosion and wall integrity?
   A: Very important that you have inspection and clean out ports in the stack and breeching system for this very reason. These openings should be removed periodically (say every 6 months) as part of your normal boiler maintenance routine. You’ll be looking for any pools of condensate and/or corrosion which could cause eventual problems and if found, take corrective action.

36) Q: If variable speed stack fans are used with modulating dampers are barometric dampers required as well?
   A: No
37) Q: Is it legal to install a drain in place of a drain valve? If so are they required at each forced draft boiler or just one at the end of the horizontal run?

   A: We talked about exhaust drains and not about boiler drains. UL103 requires that chimneys can withstand up to 60” wc of static pressure, which corresponds to approximately 2 psig. During normal operation, exhaust systems very rarely exceed +0,5” wc (or approx.. 0,02” wc). At these pressures, simple drain lines with condensate loops, like mentioned in Answer #21 can be used. These drain lines go to neutralizers that can be isolated with valves.

38) Q: Is there a rule of thumb for proper elevation of stack above roof line?

   A: This has been answered in Question #20

39) Q: You advise that contrary to ASHRAE, or some other codes that the sizing should be done under all conditions vs only at max flow and natural draft?

   A: Sizing regulations and boiler categories are based on maximum rates. However, we also want that the exhaust systems perform well at all the expected rates and at all the planned periods during the year, without safety concerns, without much higher fuel consumptions and without affecting pilots and main flames’ shapes and stabilities. We therefore try to provide solutions that can perform in all these conditions, if all this information is provided to us. If and when compromises are necessary and the sizing cannot meet ALL the expected conditions, then sizing for maximum rate always remains the priority and other accessories and controls can be provided to meet exceptional and infrequent operation conditions.

40) Q: What’s the pH of the condensate collected in the stack and what’s the recommended medium to neutralize?

   A: The pH value of condensate from low-sulphur fuel oil can range approximately between 2.3 to 4, whereas the pH value for the condensate from the combustion of natural gas is usually closer to a range of about 3.5 to 4.5. These acidic solutions can contain concentrations of nitric, nitrous, sulfuric, sulphurous, hydrochloric and carbonic acids. Some suppliers of neutralizers prefer using a high quality calcite in combination with magnesium oxide, and some others use calcium carbonate, among some neutralizing medium that are available. It is often recommended to try raising the pH at least to 5, before releasing the condensate to the sewer.

41) Q: What are some typical stack temperatures? Maximums and Minimums? That you have seen in installed applications?

   A: They vary all over the map, based on operating temperatures in the boiler, to firing rates. As a rule of thumb, a well-tuned boiler will have a stack temperature about 100 °F above its operating steam temperature at high fire. So, if you’re operating at 100 psig, the saturated temperature is about 340 °F and the stack temperature would be
about 440 °F at high fire. Minimum and maximum stack temperatures should be considered at the time a stack is designed, based on the expected dew points, the alloys used, the excess air used in combustion and the insulation of the stack. As long as sufficient draft is provided, that the right alloys are used and that the chimneys selected correspond to the right UL code, there is not really a minimum of maximum stack temperature other than the minimums and maximums exhaust temperatures of the appliances that are vented.