

Tephra® OG



CR Minerals offers a unique remediated fly ash (Tephra® OG) specifically engineered to serve the oil and gas industries as a high performance pozzolan. Tephra® OG is a specially formulated blend of fly ash and natural pozzolan yielding a very reactive and cost-effective pozzolan. In typical down-hole cement systems, this specialty pozzolan enhances the early compressive strength of cementing slurries and outperforms 100% ordinary Portland cement (OPC) mix designs in long term compressive strength. This newly available, engineered fly ash product will also reduce the permeability of the cement barrier thus ensuring a lasting seal between the annulus of the well-bore and the casing string.

Thermally Stable with Enhanced Strength

When properly formulated, Tephra® OG will immediately start to react with the free calcium hydroxide in the cement slurry to form a denser and secondary cementitious reaction. With the combination of heat and pressure in down hole cementing applications, this secondary reaction increases the early compressive strength allowing for a return to drilling operations quicker than straight OPC based slurries. The highly amorphous natural pozzolan incorporated with the fly ash will not only give greater compressive strengths than 100% OPC but will also increase the durability of the cement by consuming much of the by-product calcium hydroxide that may otherwise instigate destructive reactions with certain sulfates that are found in shales or produced water. Tephra® OG will significantly increase the durability of the concrete over the life span of the well by reducing or binding most of the available calcium hydroxide in the cement paste. This will in-turn eliminate the reaction that forms silicic acid which could otherwise lead to a destructive gel that would cause the wellbore cement to fail over time. Unlike straight fly ash, having a naturally calcined pozzolan will also allow for use in high temperature and high pressure (HTHP) applications where reducing the permeability of the cement is critical for proper zonal isolation and preventing micro-annuli formation downhole.



slurry formulation practices. With a controlled D10, D50 and D90 Tephra® OG allows for tighter particle packing of the blended cementitious components and a reduced API fluid loss to the formation. As a milled material, the surface area is increased over traditional fly ash yielding a more reactive material allowing for better primary and secondary cementing jobs in highly permeable sandstones and weak casing shoes, where uncontrollable losses of cement to the formation are costly and time consuming.

Consistency in Chemistry and Quality Control

Tephra® OG is manufactured to stringent tolerances and thoroughly tested not only for the performance data discussed here, but to ensure the product has superior properties when compared to other fly ash materials in the marketplace. We rigorously ensure consistency of particle size, shape, and chemistry thereby minimizing variability in the field. Reducing the variability in fly ash is a critical component of the value proposition of CR Minerals to our customers. Every load of Tephra® OG is QA/QC tested prior to shipment and retain samples are kept for future evaluation if needed. Testing each load of fly ash that comes in and adjusting your formulation accordingly can now be a thing of the past with the consistency of Tephra® OG.

Pozzolan Benefits

Enhances Compressive Strength

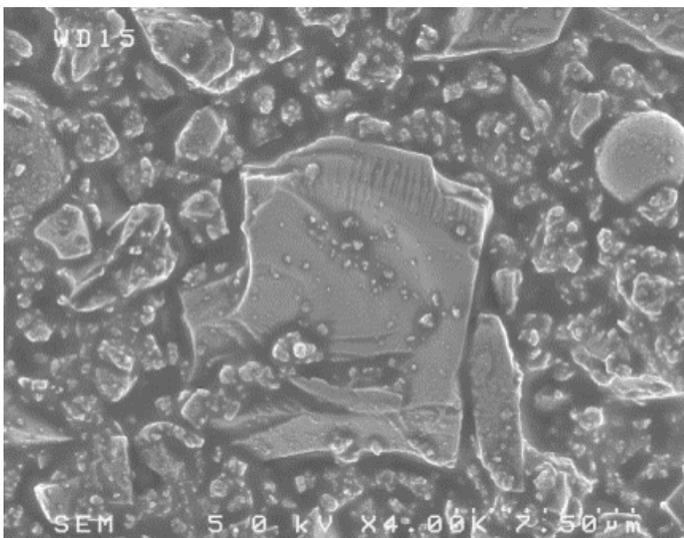
The pozzolanic reaction between Tephra® OG and excess calcium hydroxide in the concrete pore solution begins almost immediately, providing for concrete compressive strengths that are similar to or exceeding 100% OPC concrete strength in 28 days. At replacement levels of 30~50%, the resultant strengths will continue to increase well past 28 days due to the natural pozzolan component.

Mitigates Alkali Silica Reaction (ASR)

CR Minerals Tephra® OG presents a high surface area which results in a very reactive pozzolan. The product readily reacts with calcium hydroxide as it becomes available in the cement paste, and thereby incorporates the liquid phase alkali into additional C-S-H binder. By densifying the cement paste and removing calcium hydroxide as a potentially deleterious agent in the concrete, the prospect of ASR is severely mitigated. Additionally, the now denser paste and the resultant minimization of capillary action significantly reduces pore structure.

Reduces Permeability

The leaching of calcium hydroxide produced by the hydration of Portland cement can be a significant contributor to internal porosity in all Portland cement-based mixtures. Tephra® OG pozzolan will effectively reduce concrete permeability by reacting with the calcium hydroxide to form



Minimizing Lost Circulation and Increased Surface Area

Tephra® OG is a milled and blended pozzolan with particular attention given to particle size distribution (PSD) as a fundamental property for the oil and gas industry. The tight and consistent PSD curve will allow for better

stabilizing and strength enhancing C-S-H. With a controlled and consistent particle size, the reactivity of OG will help minimize gas influx and channeling in wellbore cementing operations resulting in a better protected formation and integrity of the casing.

Reduces Heat of Hydration

Experiments show that replacing 30~50% OPC with Tephra® OG pozzolan can reduce the expansion and heat of hydration by as much as 20~40%. Compared to the hydraulic reaction of water and OPC, less heat is produced when pozzolan reacts with the available calcium hydroxide, a by-product of the hydraulic reaction. Tephra® OG pozzolan not only decreases the overall heat generated by cement hydration, it also delays the time of peak temperature. The heat of hydration of a Tephra® OG pozzolan–OPC cement mixture is extended longer and lower to form a much more moderate curve than the traditional heat of hydration curve for OPC itself. Resulting in a stronger overall compressive strength, greater linear elasticity and long-term durability. Tephra® OG based slurries show an overall lower Youngs Modules and higher Poisson’s Ratio.

Shipping and Availability

CR Minerals Tephra® OG is manufactured and distributed out of our state-of-the-art facility conveniently located in Pueblo, Colorado. As proper stewards to the pozzolan industry, our goal is sustainable supply and long-term relationships with our customers. Tephra® OG is not another run of the mill pozzolan for the oil and gas industry that has wild swings in chemistry and availability depending on seasonal power plant usage. Tephra® OG is available for purchase in bulk pneumatic and rail.

Environmentally Sound

CR Minerals’ remediated fly ash pozzolans are beneficiated with the purest of natural pozzolans, calcined by Mother Nature. In combination with fly ash, the mixture of natural and artificial pozzolans creates a unique downhole material which performs similar to or better than standard fly ashes in nearly every measure of performance.

Technical Information Summary

- Bulk Density:** 48-52 lbs/ft³
- Specific Gravity:** 2.3-2.45
- Passing 325 mesh screen:** 90%+
- Water demand:** 97~101% of cement control



Recommendations for Using Tephra® OG

Replacement Dosages

Tephra® OG may be substituted for fly ash or Portland cement at various percentages depending on the specific raw material and/or performance requirements and customer goals. Typically, replacement levels are in the range of 30~50%.

Water Demand

Fly ashes generally provide a lower water demand than cement while Natural Pozzolans generally provide a water demand that is similar to or slightly higher than cement. The water demand for a concrete mixture incorporating Tephra® OG ranges from 97-101% of the OPC control.



Although the information and suggestions in this publication are believed to be correct, CR Minerals makes no representations or warranties as to the accuracy or completeness of this information.