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Research into the possibility of reusing fire-extinguishing powders and reducing laboratory waste during quality control

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Abstract

The study addresses the reutilization of fire-extinguishing powder in the context of circular economy principles. The aim of this study was to optimize the method for determining phosphate ions in order to minimize the amount of laboratory waste generated during the analysis of ammonium monophosphate (MAP) content according to ISO 7202. Comparative analysis was performed between the reference acid-base titration method and a spectrophotometric method. Optimization of the titration procedure encompassed refinement of sample preparation, adjustment of operational parameters and validation of measurement repeatability. Experimental results demonstrated that regenerated extinguishing powders, irrespective of raw material origin or applied regeneration process, conformed to all technical specifications of the PN-EN 615 standard. Implementation of this optimized methodology enables a measurable reduction in post-analysis waste. The proposed changes to the ISO 7202 standard are important for improving the organization's corporate standards in the fields of sustainability and ESG reporting.

1. INTRODUCTION

Every modern organization seeks to create more environmentally safe technological processes and devices that ensure rational use of natural resources and compliance with environmental impact standards. In 2025, the European Commission plans to approve an ambitious EU act on the circular economy that will include measures aimed at creating market demand for secondary materials and a single market for waste, especially when it involves critical raw materials [www.circulareconomy.europa.eu]. In firefighting practice, powder extinguishing compositions are widely used because of their excellent extinguishing properties. Although the actual composition of commercial powders filling fire extinguishers — specifically the ABC type — is not always easily available, it is known that their main component is ammonium dihydrogen phosphate, often called ammonium monophosphate (MAP), which may be at a percentage anywhere from 10% to 90% [Michelotti 2012]. However, the powder that is most commonly used is one containing 30-40% $\text{NH}_4\text{H}_2\text{PO}_4$ and 50-60% $(\text{NH}_4)_2\text{SO}_4$ [Gelsomino, Petrovicova, Panuccio 2024]. ABC-type fire extinguisher powders also contain various additives, including pigments, magnesium aluminium silicate, calcium carbonate (CaCO_3), and silicone oil [Michelotti 2012; Gelsomino, Petrovicova, Panuccio 2024]. The extinguishing capacity of ABC powders depends

largely on their MAP content. Phosphates are widely used in fire-extinguishing powders due to their versatility, high extinguishing capacity, and relatively low production cost. Studies of the flame-inhibition mechanism of ABC powder conducted by the authors [Li et al. 2019] using the Gaussian16 software package confirmed that fire suppression with ABC powder is mainly based on the recombination of radicals in the flame zone.

Current EU regulations stipulate that the powder must be disposed of as waste after its useful life, which is usually three to five years, depending on local regulations. Phosphates have been included on the EU list of critical raw materials since 2014, as confirmed in the EU Critical Raw Materials Act of 2024 [Regulation... 2024]. According to the European Sustainable Phosphorus Platform (ESPP), 36 million kg of used fire-extinguishing powder is stored in the European Union (EU) every year [www.phosphorusplatform.eu]. The MAP contained in ABC fire-extinguishing powders is also found in commonly used phosphate fertilizers, indicating that fire-extinguishing powder could be reused as a fertilizer substitute in agriculture, where it would help reduce the production and use of phosphate fertilizers and, consequently, the primary resources used in their manufacture [Tsigka et al. 2024; Dotelli, Viganò 2020]. Policies enabling the reuse of waste or unwanted end-of-life materials can be an ecologically friendly, fast, and cost-

effective option to promote sustainable development and efficient material management, reinforcing the principle of the circular economy [Schröder et al. 2018; Albanese, Annatelli 2024]. Phosphorus is currently considered a key element, especially in relation to social balance and planetary development. It would therefore be desirable to introduce new powder recycling procedures to preserve this element. Although reuse of ABC powders has been documented in fertilizers [Michelotti 2012; Schröder et al. 2018] or in bituminous mixtures [Praticò, Moro, Ammendola 2010], additional processes are necessary to remove any additives that are not beneficial to the environment. As part of an EU-funded project, an Italian company managed to recover phosphate from spent fire-extinguishing powder [Periodic Reporting]. However, this method of recovering phosphate involved rinsing the recovered powder with water, extracting silicone oil, and removing dye residues using organic solvents — all of which created additional waste fractions for disposal. In order to promote sustainable development policy and efficient material management, and to reinforce circular-economy principles, the best solution would be direct powder recycling.

In order to give fire-extinguishing powders a second life and produce a suitable material for new applications, additional processing is still necessary. The main stages of the fire-extinguishing powder regeneration technology are the operation of emptying powder extinguishers or packages with expired fire-extinguishing powder; homogenizing the powder; preliminary analysis of the powder's parameters; deciding on the method of modifying the powder's characteristics (drying, sieving of metal and plastic impurities, adding components to improve parameters, etc.); control analysis of the finished product in accordance with the requirements of PN-EN 615 and ISO 7202:2018 standards; and approval of the powder for packaging, storage and shipment to the end-user.

One of the important requirements for the regenerated fire-extinguishing powder production process to function correctly is the standardization of the product's MAP content. Depending on the manufacturer, the percentage of this component in the powder in the EU can range from 13% to 65%. Hazardous waste has a negative impact on the natural environment, so any company that implements ecological standards wants to minimize the amount that is produced.

Reducing the amount of waste obtained in the laboratory is an important step toward reducing the total amount of waste generated by the process. In laboratory work, the main waste consists of liquid substances from which water has evaporated, thereby creating solid waste. The amount of both liquid and solid waste largely depends on the volume of the substances used in the MAP marking process, because marking other parameters of fire-extinguishing powders is not predictive of laboratory waste. Therefore, one of the goals of this research was to assess the possibility of modifying some MAP marking procedures according to the requirements of the ISO

7202 standard in a way that allowed for the reduction of laboratory waste. The ISO 7202 standard does not use instrumental analytical methods as reference methods; therefore, they are not validated, and cannot be used as research methods for, in example, forensics. More accurate analytical methods can eliminate human error at certain stages, but are not fully used for the analysis of MAP content in fire-extinguishing powders. One exception is the spectrophotometric method, which is commonly used to determine the content of phosphates (including MAP) in mineral fertilizers. This article discusses the instrumental analytical method as an alternative research method for fire-extinguishing powders in applicable standards.

2. MATERIALS AND METHODS OF STUDY

2.1. Method of fire-extinguishing powder regeneration

In this study, various samples of regenerated fire-extinguishing powders were produced industrially and subjected to analytical tests in accordance with the requirements of PN-EN 615 [2009] and ISO 7202 [2018].

The raw material for the production of reclaimed powder was expired fire-extinguishing powder from several different European countries: Italy, Belgium, France, Poland, Norway, Germany, Greece, and Hungary. Average samples from each batch of expired fire-extinguishing powders were analysed in accordance with the requirements of ISO 7202. The main characteristics of the powders included their bulk density, resistance to caking, resistance to water wetting, moisture, sieve analysis, and metal impurities (such as pieces of steel or iron, rust particles from fire extinguishers, and the like). Depending on the discrepancies between the parameters and the requirements of ISO 7202, the powders were subjected to various stages of regeneration. The main stages of fire-extinguishing powder regeneration technology include drying; exposure to a magnetic separator to remove metal impurities; sieving to remove any plastic impurities; and adding components to improve parameters (silicone oil, silicon dioxide, ammonium sulphate, etc.). The powders went through various stages of impurity separation and were mixed and modified in such proportions such that the MAP content was at the appropriate level indicated in the Safety Data Sheet for ABC NTL GREEN fire-extinguishing powder. The main components of the powder are were $\text{NH}_4\text{H}_2\text{PO}_4$ ($32 \pm 2\%$), $(\text{NH}_4)_2\text{SO}_4$ ($62 \pm 2\%$) and additives ($\sim 5\%$), with the following content levels of heavy metals: As < 0.5 ppm, Cd < 0.2 ppm, Hg < 0.2 ppm, Ni < 2.0 ppm, Pb < 0.5 ppm, and Se < 0.5 ppm.

2.2. Methodology for determining granulometric parameters

Granulometric parameters were determined according to the requirements of PN-EN 615 using a set of sieves

compliant with the ISO 3310-1 standard with a nominal diameter of 200 μm and individual mesh sizes of 125 μm , 63 μm and 40 μm , together with a lid and a collection bowl. The set of sieves was placed on a mechanical sieving device, which moved the set in an ellipse on a horizontal plane. Sieving the extinguishing powder took 10 ± 0.2 minutes. The result was considered valid only when all powder masses collected by the sieves were equal to the initial amount with an accuracy of $\pm 2\%$.

2.3. Preparation of standard solutions and standard mixtures

Ammonium dihydrogen phosphate, manufactured by Chempur, has a MAP content of 99.60% according to its quality certificate and absorbs water during storage. Therefore, prior to use in determining the fire extinguishers' MAP content, it was dried over concentrated sulfuric acid for 48 h (± 2 h) in a desiccator. A phosphate solution with a concentration of 10 mg $\text{PO}_4^{3-}/\text{dm}^3$ was prepared by dissolving $\text{NH}_4\text{H}_2\text{PO}_4$ in deionized water (DW). Analytical-grade ammonium sulfate (Warchem) was dried at 105°C for 2 h.

A standard extinguishing powder with MAP content of 32.00% was prepared as a mixture of $\text{NH}_4\text{H}_2\text{PO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot \text{SiO}_2$, with a final ratio of 32.00%: 63.00%:5.00% for the three components.

2.4. Determination of $\text{NH}_4\text{H}_2\text{PO}_4$ by the acid-base method according to ISO 7202 (p. 13.10)

Potassium chloride (p.a., Eurochem), used to test MAP content by titration method, was dried at 110°C for 2 h. A 2.5-g sample of extinguishing powder was homogenized with 10 ml acetone (PureLand) for 10 min at room temperature and for another 30 min after adding 150 ml of water. The solution, heated to 85°C for 15 minutes, was filtered into a 250ml volumetric flask. After cooling, the flask was filled to the mark with distilled water; 50ml of the solution was taken, and 20g of potassium chloride is added. All tested solutions were titrated with a titrant of 0.1 M sodium hydroxide (PureLand) to pH 7.9 using a Titrette automatic burette. A PL-700 PVC pH meter was used to measure pH for determining the MAP content using the titration method.

2.5. Determination of $\text{NH}_4\text{H}_2\text{PO}_4$ by the UV-VIS spectrophotometric method

The MAP content was determined in accordance with the requirements of the GOST 20851.2-75 standard. The methodology was modified so that the total phosphates from the 0.025 g sample weights of fire-extinguishing powders were extracted using a mixture of acetone,

nitric acid, and DW at a 1:1:2 ratio. They were then heated for approximately 5 minutes and filtered into a 250-ml volumetric flask. Blank samples without MAP were prepared in a similar way.

The standard curve method was used to perform quantitative spectrophotometric determinations of MAP content. The rectilinear course of the standard curve in the tested range — which passed through the origin of the coordinate system — indicates that the system complies with the Beer-Lambert law. All samples were prepared in triplicate. The basis of the spectrophotometric method with vanadomolybdic acid was the reaction of orthophosphate ions with ammonium molybdate in the presence of vanadium. In an acidic environment, a yellow-colored vanadophosphoromolybdate complex was formed. Its absorbance was measured using a double-beam UV-VIS spectrophotometer (an AOE Instruments ELAB A560PC), at a wavelength of 440 nm, in a cuvette with an optical path length of 1 cm.

The experiments were conducted at room temperature at $20 \pm 2^\circ\text{C}$. Data were collected using Microsoft Excel and then statistically evaluated.

3. RESULTS AND DISCUSSION

The acid-base titration method enables quantitative characterisation of the tested material, and has been in use for almost 100 years [GOST 3771-74; Dijkstra 1949; Hulanicki 2008]. The aim of this study was to optimize the process of titration of the phosphate ions in the presence of potassium chloride in order to reduce the amount of laboratory waste generated during MAP determination. The definition of waste according to EWC Code 16 05 06 was used: "laboratory chemicals, consisting of or containing hazardous substances, including mixtures of laboratory chemicals." The procedure was carried out in accordance with p. 13.10 of ISO 7202:2018. The optimization analysis covered the method of sample preparation, the determination of appropriate technical parameters during the titration process, and obtaining reliable and repeatable results. The studies were conducted on model solutions of $\text{NH}_4\text{H}_2\text{PO}_4$ based on the standard in the presence of varying amounts of potassium chloride, which stabilized the ionic strength of the system.

The proper preparation of powder samples for measurement was of great importance in the acid-base titration process. The main problem at this stage was the prepared solutions' absorption of carbon dioxide absorption from the atmospheric air. Carbon dioxide sorption must also be minimized during the titration process with sodium hydroxide solution. Carbonate ions formed in the solution are undesirable, because their presence leads to increased titrant consumption during analysis, potentially leading to overestimations of the MAP content in the analysed samples by as much as 0.1 to 0.3% [Boguta, Sokołowska 2010]. The most important parameters include the volume of the added titrant portion, the dosing rate of subsequent titrant portions,

and the pH range of the titration endpoint. The addition of potassium chloride stabilized the ionic strength of the system and thus prevented fluctuations in the measured pH.

The amount of potassium chloride recommended by ISO 7202 for testing MAP content in a single sample replicate is 20 g. Considering the influence of other components on the extinguishing powder solution's ionic strength, it is not always possible to dissolve the required amount of KCl in the solution quickly enough. At the same time, extending the mixing time increases the possibility of absorption of carbon dioxide from the atmospheric air and leads to increased NaOH consumption during analysis, consequently leading to overestimation of the MAP content in the analysed samples. Because other standards suggest using smaller amounts of KCl to stabilize the ionic strength of the system during MAP content testing [GOST 3771-74; Joint FAO/WHO 1980], the influence of potassium chloride content, in amounts smaller than the generally accepted standard, was tested. The results of testing the influence of potassium chloride content on the determination of MAP content are presented in Table 1.

During the study, it was noticed that fast dosing in excess of the volume of the dosed titrant (0.5 ml), in the presence of smaller amounts of potassium chloride, did not cause pH drift or slower equilibrium. This was related to the pH range of the phosphate buffer, which begins at approximately 5, reaches approximately 6.5, and ends between 7.8 and 8.0 [Boguta, Sokołowska 2010].

The results of the analysis show that different amounts of KCl used during the determination will slightly affect the percentage of MAP in the analysed sample. This change will reduce laboratory waste and its consequential environmental impact.

After analysing the above data, we propose specifying the technical parameters of the process of determining MAP content by the titrimetric method according to the ISO 7202:2018 standard. Table 2 presents the normative conditions and proposals for modifying some of the procedures used to determine MAP content.

It is known that in the process of mixing the sample, energy is used to set the solvent (acetone or acetone-DW mixture) in motion, as well as to maintain this motion. The shape or volume of the beaker, among other factors, affect the mixing power. Therefore, determining not only the capacity of the beaker, but also its maximum diameter, will allow for optimal liquid column height when mixing the sample and will unify the mixing parameters when determining the MAP content using the titrimetric method.

Mixing the sample in the presence of acetone, according to ISO 7202:2018 takes place in open beakers without a cover. Due to acetone's high volatility, toxicity, and flammability, it would be highly recommended to cover the beaker with a watch glass immediately after adding acetone to the sample. Determining the sample mixing time (10-12 min in the presence of acetone and 30-35 min in the presence of water) — as well as the speed of containment at the stage of extraction and titration of phosphates (300 rpm) —

Table 1. Test results of the effect of potassium chloride content on the determination of MAP content in accordance with ISO 7202 (n = 3, P = 0.95)

Lp.	Quantity KCl/g	Quality certificate % MAP	Found MAP [%]
1	10	99.60	99.79 ± 0.15
2	12		99.63 ± 0.17
3	14		99.56 ± 0.19
4	16		99.99 ± 0.17
5	18		99.92 ± 0.15
6	20		99.97 ± 0.16

Source: Own elaboration

Table 2. Normative conditions according to the requirements of ISO 7202:2018 and proposals for modification of some procedures for determining the MAP content

Action	Current text of ISO 7202:2018 (p. 13.10)	Proposed modification of the procedure
Sample preparation	The beaker capacity is determined to be 600 ml	Also determine the maximum diameter of the beaker (70 mm)
	Cover the sample with a watch glass while heating	Cover the sample with a watch glass after adding acetone and DW, as well as during heating
	Mixing the sample with acetone for no less than 10 min	Also determine the maximum mixing time (10 to 12 min)
	Mixing the sample with WD for no less than 30 min	Also determine the maximum mixing time (30 to 35 min)
	Mixing the sample (mixing speed not specified)	Also determine the maximum mixing speed (300 rpm)
	After the sample has cooled from 25 to 20° C, fill to the mark	After reaching the temperature of 20±2° C, fill to the mark
Titration	Add 20 g KCl and 20 ml WD	Add 10 to 12 g KCl and 5 to 10 ml DW
	Mixing the sample (mixing speed not specified)	Also determine the maximum mixing speed (300 rpm)
	Titrate to pH 7.2 to 7.7	Titrate to pH 7.85 to 7.90

Source: Own elaboration

limits the possibility of absorption of carbon dioxide from atmospheric air and increases NaOH consumption during the analysis. It was previously reported that the amount of KCl used during MAP determination has a minor effect on the final MAP content. Therefore, reducing the amount of added KCl and DW to 10–12 g and 5–10 ml, respectively, will reduce the amount of laboratory waste generated.

More stringent requirements for solution temperature when filling the volumetric flask to the mark are related to the fact that volumetric flasks are generally calibrated at 20° C. It must also be taken into account that a change in temperature causes a change in the density of the liquid, which can cause inaccurate solution concentrations and discrepancies in the determination of MAP content in different laboratories. Giving such a wide pH range of as the end point of titration (7.2 to 7.7) can also cause such discrepancies in the determination. Therefore, we propose specifying a more precise pH range, and changing the end point of titration to pH 7.85–7.90, which is used in other phosphate determination methods [Boguta, Sokołowska 2010; Dijkman 1949].

When MAP content is calculated according to ISO 7202, if 20 g of KCl is used, a company producing 2,000 tons per year of regenerated fire-extinguishing powder produces about 55 kg of laboratory waste annually. When half as much KCl (10 g) is used to analyse one sample, it generates half as much waste. Waste generated during research is classified as hazardous under EWC Code 16 05 06. As such, the collection, labelling, storage, transportation, and disposal of such waste requires adherence to specific rules to ensure safety and minimize environmental and health risks. Waste minimization thus brings numerous benefits for the environment, the economy and society — saving raw materials, reducing environmental pollution, lowering disposal costs, improving corporate image, and building better social relationships.

The proposed changes to the ISO 7202 standard modification are important for improving organizations' corporate sustainability and ESG-reporting standards.

The correct determination of the phosphate content in fire-extinguishing powder samples is critical for determining their main parameters. Phosphorus can be measured using spectrophotometric, spectrometric, and ion-chromatography instrumental methods. As an alternative to testing the content of ammonium monophosphate in fire-extinguishing powders, the ISO 7202 standard proposes a slight modification of the acid-base titration method (Annex E), which precludes the identification of adulterated MAP content in powders containing substances with strong buffering properties.

Due to the numerous advantages of instrumental methods over conventional methods of chemical analysis, a comparative study of MAP determination was carried out using two analytical techniques: the referenced acid-base titration method [ISO 7202:2018] and the non-reference spectrophotometric method, modified in the manner described earlier. For quality control — to determine the correctness of the method for determining MAP in fire-

extinguishing powders — an analysis was made using a certified reference material that consisted of a mixture of MAP standard and ammonium sulphate. All experiments, both spectrophotometric and titration, were performed on samples of fire-extinguishing powders produced industrially from raw materials originating from specific combinations of European countries. Sample no. 1's ingredients were from Belgium and France, sample no. 2's were from Italy and Poland, sample no. 3's were from Norway and Germany, and sample no. 4's were from Greece and Hungary. The powders were subjected to a regeneration process and modified. The raw material was selected such that all its physicochemical parameters, including MAP content, met the requirements of the PN-EN 615 standard and the parameters indicated in the Safety Data Sheet for ABC NTL GREEN fire-extinguishing powder. The duration of all the activities concerning spectrophotometric and titration determinations was strictly observed in accordance with the given methodology, as shown in Table 3.

MAP content measurements were performed for four samples and the certified material, which was a mixture of certified standards $\text{NH}_4\text{H}_2\text{PO}_4$ at 32% and $(\text{NH}_4)_2\text{SO}_4$ at 68%, and was labelled sample no. 5. The samples were tested according to both methods, and the results are presented in Table 4.

The results of the analysis indicate some differences in the phosphate content determined by the two different analytical techniques. When using acid-base titration, the MAP content of samples no. 1 and no. 2 appeared to be lower than when using the spectrophotometric method, while the MAP content in samples no. 3 and no. 4 seemed higher. The permissible relative error for both methods was 15%. Although the difference between the results obtained by the two different methods is not large, amounting to only 0.34%, the spectrophotometric method required only a third of the time to test the MAP content in one sample, generated 20 times less laboratory waste during the tests, and yielded a higher accuracy than the titration method; the obtained results met all the assumed acceptability criteria. Other technical parameters of the industrially manufactured fire-extinguishing powders were also tested in accordance with the PN-EN 615 standard.

The results presented in Table 5 confirm that the properties of the powders correspond well to the principles of the technical data sheet for ABC extinguishing powder. There were not any significant differences in data quality regardless of the origin of the raw material. This confirms our hypothesis that the powder after regeneration would fully comply with all the requirements of the PN-EN 615 standard and would be usable to fill powder extinguishers.

4. CONCLUSIONS

Analysing the literature data and the author's practical experience yields a modern solution to the problem of reusing extinguishing powder from a circular-economy perspective. Based on the characteristics found in this

Table 3. Comparison of the sequence of operations and time of MAP content determination using the reference method vs. the spectrophotometric method

Action	Titration method	UV-VIS method
	Time (min)	
Weighing the sample	1	2
Adding reagents	1	1
Mixing without heating	40	-
Heating	25	5
Filtering	20	5
Cooling	25	-
Preparing for analysis	7	23
Taking the sample	1	-
Titration	5	-
Absorbance measurement	-	1
Sum	125	37

Source: Own elaboration

Table 4. Comparison of MAP content test results for ABC NTL30 fire-extinguishing powder samples using the titrimetric method and the spectrophotometric method ($n = 3$, $P = 0.95$)

Sample No.	UV-VIS method	Reference method
	MAP content in fire-extinguishing powder samples, %	
1	32.11 ± 0.04	31.72 ± 0.26
2	33.50 ± 0.09	33.20 ± 0.16
3	33.77 ± 0.08	34.02 ± 0.12
4	33.44 ± 0.10	33.85 ± 0.12
mixture of patterns (MAP – 32.00%)	31.96 ± 0.09	32.25 ± 0.14

Source: Own elaboration

Table 5. Technical parameters of regenerated ABC extinguishing powders (average of three repetitions) in accordance with the PN-EN 615 standard

Sample No.	Bulk density (g/ml)	Resistance to caking	Resistance to water wetting	Fire test performance	Moisture (%)	Sieve analysis (%)		
						> 125 μ m	> 63 μ m	> 40 μ m
1	0.91	yes	yes	yes	0.11	13.7	41.1	64.8
2	0.94	yes	yes	yes	0.14	13.4	45.4	62.9
3	0.92	yes	yes	yes	0.10	12.1	39.2	60.9
4	0.89	yes	yes	yes	0.17	14.0	41.4	64.8

Source: Own elaboration

study, it can be confirmed that the technical parameters of the regenerated extinguishing powders, regardless of the origin of their raw materials and their subsection to various regeneration stages, fully satisfy all the requirements of the PN-EN 615 standard.

The optimal conditions for titration during the MAP determination were examined according to the requirements of the ISO 7202:2018 standard. The following modifications were proposed to the technical parameters for the process of determining phosphates by titration (p. 13.10) according to the ISO 7202:2018 standard:

- specify the maximum diameters of the beakers used for phosphate extraction and titration, as well as the speed and duration of sample mixing, in order to limit contact of the solution with air (and thus CO₂ sorption and carbonate formation);
- reduce the amounts of KCl and DW added in order to reduce the generated by the laboratory; and
- change the pH end point of titration to a range of 7.85–7.90 in order to obtain reliable and repeatable results.

This study compared two methods for determining phosphate content in fire-extinguishing powders: the reference acid-base titration method and the spectrophotometric method. The results of the study showed comparable phosphate concentration values after using both analytical techniques, indicating that the UV-VIS method is an adequate alternative to reference methods for determining the phosphate content of fire-extinguishing powders. Compared to the current standard method, the UV-VIS method is characterised by speed and ease of execution, and is suitable for quantitative analysis of MAP in fire-extinguishing powders. The tests also generated 20 times less laboratory waste. The proposed amendments to the ISO 7202 standard address environmentally-friendly activities and products aimed at environmental protection and sustainable development that would:

- reduce costs related to the purchase, transport and storage of reagents;
- reduce energy consumption;
- reduce laboratory work hours;
- reduce costs related to storage, packaging, transport and waste disposal;

- reduce organizations' carbon footprint according to Scope 1 (direct emissions), Scope 2 (energy-related indirect emissions), and Scope 3 (other indirect emissions);
- improve the organizations' corporate standards for sustainability and ESG reporting.

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